

Quality Assurance Project Plan and Management Plan for **Landfill Biofilters Project**

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Per [EPA IT/IM Quality Assurance Project Plan \(QAPP\) Standard](#) as of November 5, 2024,
work products that rely on Environmental Information Operations

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Section A: Project Management and Information/Data Quality Objectives

A.1 Approvals Page

_____ Signature of Project Manager Mary Lambert, Project Manager Hudson Valley Regional Council	_____ Date
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_____ Signature of Interim Project Quality Assurance Manager Ryan Corbett, QA Manager Hudson Valley Regional Council	_____ Date
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_____ Signature of EPA Regional Project Officer Valerie Askinazi, EPA Regional Project Officer EPA region 2	_____ Date
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_____ Signature of EPA Regional Quality Assurance Manager or Designee (EPA Regional Quality Assurance Manager or Designee) EPA region 2	_____ Date
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QAPP Revision History

Version No.	Description of Changes	Author	Date
1.0	Original Version	Mary Lambert	03/15/25
1.1	Incorporated feedback from EPA	Mary Lambert	04/22/25

A.2&3 Project Background and Definition

The Mid-Hudson Region has dozens of small, closed municipally owned closed landfills as well as some larger county-owned closed landfills. Dozens of the Region's local governments have completed emissions inventories and climate action plans. Hudson Valley Regional Council (HVRC) staff has observed through our technical assistance to these municipalities that closed landfills are often the largest source of emissions for the government operations of many municipalities, as modeled using the EPA's LandGEM tool. Landfills emit significant emissions because 40-60% of landfill gas (LFG) consists of methane (CH₄), which is 84–87 times more potent at trapping infrared radiation than carbon dioxide (CO₂). In addition, low-level LFG production may continue up to 100 years after landfill closure. (Huber-Humer et al., 2008.)

Beyond methane, landfills can also release a variety of toxic pollutants, including volatile organic compounds (VOCs). This landfill gas (LFG) is harmful to health, and can cause respiratory illnesses, neurological disorders, and other chronic conditions. Methane generation from landfills is a long-term process, typically persisting for up to 50 years after a landfill's closure, as organic waste continues to decompose anaerobically (Popov 2005). However, even after this primary phase of methane production declines, low-concentration landfill gas (LFG) emissions can continue for nearly a century, albeit at reduced rates (Mønster et al. 2019; Manasaki et al. 2021).

The total estimated GHG emissions from 14 older landfills in the Mid-Hudson Region from 2025-2030, calculated using EPA's LandGEM tool, is 185,640 MT CO₂e. However, this estimate may be low. Recent research suggests that landfill models like LandGEM may underestimate emissions, as "point source emissions at landfills and large magnitude of aerial emissions rates point to potential gaps in landfill models" (Cusworth et al., 2024). This indicates the potential for significantly higher actual emissions than our estimates.

HVRC, a regional governmental entity representing the seven counties of the Mid-Hudson Region, is partnering with 14 local governments to install biofilters and native plantings on municipal landfills to reduce methane and other landfill gases. The project also aims to expand pollinator pathways adjacent to the landfills to strengthen ecosystem resilience. Additionally, it seeks to identify suitable landfill sites for solar farms, minimizing impacts on agriculture, residential areas, and sensitive ecosystems.

A.4 Project Purpose

The primary intent of the project is to mitigate GHG and VOC emissions by installing biofilters on 14 landfills listed below. The biofilters are being used with passive gas collection to capture escaping emissions at older, capped landfills past peak gas production and at landfills where gas collection is no longer economically or technically feasible. (Huber-Humer et al., 2008.)

Adding biofilters to closed landfills is a low-cost method to remove methane from landfill gas (LFG). Biofilters rely on aerobic degradation through methane-oxidizing bacteria (methanotrophs) to convert methane into less harmful compounds like carbon dioxide. A handful of landfill experimental studies have documented significant methane reductions using biofilters or biocovers. Biofilters are a more compact and targeted variation of biocovers, designed to enhance methane oxidation and reduce LFG emissions in specific areas. While biocovers typically consist of large-scale engineered layers of organic or mineral material applied over a landfill surface, biofilters are smaller, contained systems that concentrate microbial activity to efficiently break down methane and other gases in localized zones.

The literature documents that biofilters can remove methane from closed landfills at a rate of up to 90%. (Duan et al., 2021; Gebert & Grongroft, 2005; Haubrichs & Widmann, 2006; Huber-Humer et al., 2008; Pecorini et al., 2020.) Methane uptake rates can be affected by moisture content, temperature, and soil properties. Research shows that high oxidation capacity is associated with coarse, porous soil rich in organic matter and has increased with more moisture. (Haubrichs & Widmann, 2006; Pecorini et al., 2020.) The most effective media are wood chips, bark mulch, and compost. (Huber-Humer et al., 2008.)

Biofilters will be built at the gas vents on the closed landfills listed below. Initial monitoring will be conducted to determine the LFG flow rate and the concentration of methane being emitted from each gas vent. This will determine the number, location, and sizes of the biofilters for each landfill. These biofilters will consist of a combination of woody mulch and compost material. Participating municipalities with landfills have submitted letters of commitment to this project. HVRC will work with the participating municipalities to manage design, installation, monitoring, and maintenance of biofilters on their landfills. HVRC will also work with NYS Department of Environmental Conservation (DEC) to ensure each landfill's site management plan is updated to meet DEC land-use change requirements. If the municipality has not yet explored the option of landfill solar or battery storage, HVRC will work with them to publish an RFP and select a vendor that will lease the land for installation of solar and/or battery storage. If baseline monitoring reveals that there is little to no methane being emitted from a municipal landfill, we will identify other landfills in the Region on which to implement the project.

Installation of biofilters will happen in phases, beginning with several landfills that will serve as pilot sites: Beacon, Dutchess County, New Paltz and Philipstown. Lessons learned from pilot landfills will be applied to the design and installation of biofilters at the rest of the landfills. Methane monitoring will occur monthly for the first two years after biofilter installation. After the first two years, monitoring will move to quarterly. All biofilters will be inspected during monthly monitoring and biofilter material will be added as necessary. Maintenance is not anticipated to be significant, save for external factors like flooding or animal interference.

Municipalities and County governments that have submitted letters of commitment are:

1. City of Beacon (Dutchess County)
2. Dutchess County
3. Town of Amenia (Dutchess County)

4. Town of Bethel (Sullivan County)
5. Town of Cornwall (Orange County)
6. Town of Gardiner (Ulster County)
7. Town of Hurley (Ulster County)
8. Town of New Paltz (Ulster County)
9. Town of North East (Dutchess County)
10. Town of Philipstown (Putnam County)
11. Town of Rhinebeck (Dutchess County)
12. Town of Wallkill (Orange County)
13. Town of Woodstock (Ulster County)
14. Village of Mamaroneck (Westchester County)

The Project Workplan (Appendix C) outlines the features and associated individual tasks, deliverables, milestones, and responsible parties for the project. By monitoring methane emissions, installing biofilters, assisting municipalities in pursuing solar and/or battery storage on landfills, and ecologically restoring the landfills, this Project will reduce emissions on these landfills.

HVRC will partner with the New Jersey Institute of Technology (NJIT) on an education and communications campaign featuring community events, webinars and workshops to engage the public and municipal staff. The initiative will educate communities about their local landfills, promote the use of methanotrophs and biofilters for methane reduction, and foster collaboration between municipal and residential stakeholders to improve materials management and reduce landfill dependence.

The Project intends to develop new research and data to address the efficacy of biofilters in reducing methane emissions. With positive results and greater awareness, biofilters could become a more robust, scalable and widely adopted solution for reducing methane emissions in the over 10,000 inactive landfills across the U.S., as well as in various other industries and environments.

A.5 Project Task Description

The project workplan objectives can be summarized as follows:

- Objective 1: Monitor methane emissions from closed landfills and calculate baseline LFG concentrations and GHG estimates for baseline year.
- Objective 2: Install biofilters adjacent to Landfill vents.
- Objective 3: Evaluate solar and/or battery storage on Landfills.
- Objective 4: Evaluate efficiency of emissions reduction.
- Objective 5: Support biodiversity and climate resilience on Landfills.
- Objective 6: Share knowledge about reducing emissions and productive reuse of Landfills.

Objective 1: Monitor methane emissions from closed landfills.

Biofilter Site Review & Assessment

At the 14 landfill sites, the Project Technical Team (PTT) will conduct an assessment to determine current landfill vent and methane production status, as well as the optimal placement and design of biofilters. The tasks included in this phase:

- Research, Regulatory Compliance & Stakeholder Engagement:
 - Review of NY State post-closure monitoring and maintenance plans for 14 landfills to ascertain any relevant details and/or requirements.
 - Draft plan appendices on biofilter implementation as required by NYS Department of Environmental Conservation (DEC).
 - Review relevant EPA and state regulations to ensure adherence to EPA and state landfill regulations and rules.
 - Meet with key stakeholders (landfill operators and managers, as well as municipal staff and elected officials), confirm landfill access and required permissions. It is anticipated that no additional permits are required.
 - Review existing engineering plans
- Initial Landfill Evaluation
 - Identify and map, or obtain maps of, the locations of existing LFG vents, especially underground mapping or potential pipe network, from review of the Post-Closure Monitoring and Maintenance Manuals and other relevant monitoring and maintenance plans.
 - Conduct landfill site visits to confirm landfill layout, as well as topographical, wind and cellular connectivity observations. Also note landfill border characteristics ecosystems, especially bodies of water.
 - Vent assessment: number, characteristics, structural integrity and operational status of vents, distance between vents.
- LFG Evaluation
 - Initial LFG evaluation using LICOR Trace Gas Analyzer.
 - Local Vent Measurements: methane (CH₄), carbon dioxide (CO₂), oxygen (O₂), nitrogen (N₂), temperature and pressure and ideally trace volatile organic compounds (VOCs).

- Ecosystem Measurements: date, season, temperature, barometric pressure, weather conditions and wind direction and velocity.

The following is an overview of two methods to measure and analyze baseline LFG gas composition, quantity, pressure and flow.

Method 1 Flux Chambers. This method entails connecting [LICOR's 7810](#) Trace Gas analyzer to a LICOR [Smart Flux Chamber](#), to measure real-time CH₄ and CO₂ flux emissions. Chambers placed over the vents to trap gases and methane concentrations/fluxes are measured over time to calculate LFG emissions. Connecting the flux chamber to the gas analyzer will allow the team to determine the flux or flow of methane out of the biofilter. This is critical to extrapolating the overall emissions reduction from biofilter installation.

LICOR's 7810 Trace Gas analyzer is engineered for long-term stability and precision, minimizing the need for frequent recalibration. However, user-performed calibrations, including zero and span calibrations, will be performed to account for environmental changes, and to maintain measurement accuracy and ensure data quality.

- User Calibration: zero and span calibrations performed prior to each usage. Note that environmental conditions may prompt more frequent calibration.
- Factory Recalibration: on an as-needed basis, if performance issues arise.
- LICOR's Smart Flux Chamber is designed for minimal maintenance and does not require routine factory service or regular calibration. However, periodic inspection of components such as gaskets, filters, and internal connections will be performed to ensure optimal performance. Additionally, data quality will be monitored regularly and, if anomalies occur or performance issues are suspected, LI-COR support will be contacted. The flux chamber is designed to be portable and self-powered, with long-lasting batteries. It achieves air mixing without the use of a fan, thus eliminating the need for an external power source for fan operation.



Different flux chamber products

The major steps for this method are as follows:

- Place up to 8 flux chamber(s) over vent(s). Flux chambers consist of a cylindrical metal frame and an airtight lid, sometimes equipped with an electric fan. The total volume of the flux chamber should be on the larger side (e.g. est. 15 L).

- Measure each sample point for 2–5 minutes to ensure consistent readings and adequate sample flushing.
- Calculate emission fluxes using the concentration change over time.
- Calculate total emissions by multiplying the average emissions flux with the corresponding emission surface area. The corresponding emissions surface area is the surface area of the biofilter, plus any exposed side surfaces of the biofilter.

Method 2: Surveys. This method involves using a handheld gas analyzer or portable detector to measure and map the concentration of gases. This approach entails using both LICOR's 7810 Trace Gas analyzer as well as a gas flow meter -- such as the McMaster Carr [Remote-Reading Airflow/Temperature Meter](#) or the FLUKE-922 Micromanometer pitot tube -- to measure real-time CH₄ and CO₂ flux emissions.



The major steps for this method are as follows:

- Drill a small hole (approximately 0.5-1 inches) into each vent where possible, approximately 2-3 feet above grade surface to create a gas sampling port.
- Insert the flow meter and gas analyzer into each drilled hole to measure and record flow / air velocity, CH₄, CO₂, O₂ concentrations, and temperature inside each vent once a minute for 10-15 minutes.
- Insert the airflow/temperature meter into the drilled hole to measure airflow and temperature simultaneously.
- Save timestamped readings on an SD card in excel.
- Connect Analyzer to a cell phone for live data and to configure the instrument. ([Trails GPS app for iPhone](#), [GEGraph](#) and [GE-Graph for Google Earth](#) can be used for these purposes and for data visualization. LFG concentration data and GPS data can be merged in Excel.)



- Calculate CH₄ and CO₂ emissions using equations below:
 (1) $E = C * V$
 where:
 E = Emission rate (lb/d),
 C = monitored concentration (%).

$$(2) \text{CO}_2\text{e} = (\text{E}_{\text{CH}_4} * \text{GWP} + \text{E}_{\text{CO}_2}) * 365 \text{ d/yr} / 2,204.6 \text{ lb/metric ton (MT)}$$

where:

CO_2e = Carbon dioxide equivalents, and

GWP = USEPA global warming potential for methane = 28.

$$(3) Q = q_{\text{STP}} * \rho_{\text{Agg}} * 1,440 \text{ min/day}$$

where:

q_{STP} = volumetric gas flow (scfm), and

ρ_{Agg} = calculated aggregate vent density (lb/ft³), and

Q = gas flow rate (lb/d).

$$(4) \rho_{\text{Agg}} = \text{C}_{\text{CH}_4} * \rho_{\text{CH}_4} + \text{C}_{\text{CO}_2} * \rho_{\text{CO}_2} + \text{C}_{\text{O}_2} * \rho_{\text{O}_2} + \text{C}_{\text{N}_2} * \rho_{\text{N}_2}$$

where:

C_{CH_4} = methane concentration (%),

ρ_{CH_4} = methane density (lb/ft³), and

$\text{C}_{\text{N}_2} = 100\% - (\text{C}_{\text{CH}_4} + \text{C}_{\text{CO}_2} + \text{C}_{\text{O}_2})$.

$$(5) q_{\text{STP}} = q_{\text{Act}} * (\text{TSTD} / \text{TAct}) \text{ [Ideal Gas Law]}$$

where:

q_{Act} = Actual Air Flow (acfm),

TSTD = Standard Temperature (520 R), and

TAct = Actual Monitored Temperature (R).

- Methane concentrations are anticipated to be wide ranging (between 0.1 and 40%).
- LFG concentrations (CH_4 , CO_2) will be estimated daily (lb/day) and pro-rated annually (lb/year).
- GHG estimates will be calculated on an annual basis (MT $\text{CO}_2\text{E/year}$).

Note on Challenges Associated with Methods

Method 1: The flux chamber method requires vents that will fit a flux chamber over them, as well as multiple vents within a 50-foot radius of each other for multiplexor usage. If there are no vents that will fit a flux chamber over them, this method will not be utilized for pre-biofilter installation. If there are no vents close enough to each other, the multiplexor will not be used. If the multiplexor is used, it would be left onsite for up to 4 weeks and as such would require electricity and solar panels to power the electricity.

Method 2: The survey method involves measuring LFG quantity and flow independently and so introduces some margin for error in calculating overall concentrations. Additionally, it may be challenging to determine LF fluxes independent of atmospheric fluxes.

After consideration of factors above, as well as additional factors such as cost and availability, the Team will determine the most appropriate method to use for this project.

Note on Eddy Covariance Method



The [Eddy Covariance method](#) was also considered for this project. This method estimates gas flux from the covariance between vertical wind speed and the gas concentration measured at a carefully chosen height above a surface. While it provides automation for continuous measurements, this method was ultimately rejected based on the following factors:

- The size, weight and expense of the high-performance equipment as well as corresponding expertise needed to analyze data collected exceeds the scope and budget of this project
- The minimum duration required for in-situ measurements does not meet the schedule requirements of this project period.

Note: Impact of changes in barometric pressure on landfill methane emissions

Special attention will be paid to identifying variations in data changes across barometric and atmospheric pressure systems and seasonal changes. Attempts will be made to take measurements during all seasons and during both low- and high-pressure fronts /rising and falling barometric pressure, since landfill methane emissions strongly depend on changes in barometric pressure, a phenomenon called barometric pumping, which has been documented to fluctuate as much as a 35-fold variation in day-to-day methane emissions due to changes in barometric pressure. (Liukang Xu, [Impact of changes in barometric pressure on landfill methane emission.](#))

Public Engagement:

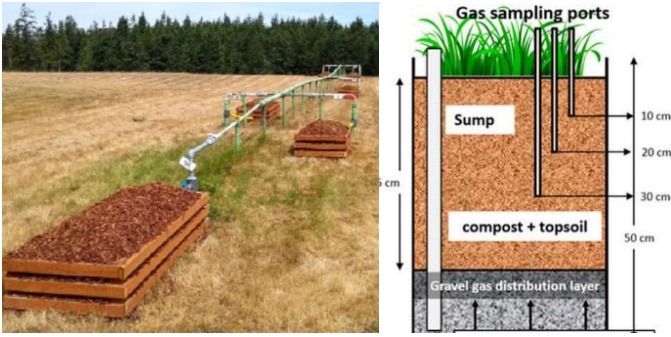
- Work with partner NJIT to educate the region on landfill methane, the Biofilters Project, as well as using landfills for potential solar electricity production, as well as for pollinator pathways.

Other

- Monitor potential odors (and ideally secondary gas emissions such as VOCs) for later comparison post biofilter implementation.
- Evaluate vents for compatibility with biofilter deployment.
- Note: Criteria include slope and proximity to physical structures and to sensitive ecosystems to minimize unintended impacts.
- Develop a strategic plan for installing biofilters in locations where they can achieve maximum methane mitigation.
- Conduct surveys to ensure the landfill cap can support biofilter and monitoring materials.
- Note: Materials on the landfill must maintain a pressure below 10 PSI, according to NYS DEC, Division of Materials Management.
- Draft RFP for biofilters consultant to assist on LFG GHG emissions calculations, as well as for ongoing and continued quality assurance.
- Draft RFP for biofilter design.

Objective 2: Install biofilters to reduce methane emissions from closed landfills

The data gathered in Objective 1 will help define the scope of the project and how to address implementing Objective 2.



Example biofilter installation and cross-sample

Biofilter Construction: passively route LFG to biofilter

- Determine quantity of biofilters needed. Determining the number of biofilters needed for a landfill will require an analysis of vent-specific data.
- Hire a consultant to design the biofilters. Considerations for biofilter design will include:
 - Choose appropriate lower-level permeable aggregate material to ensure adequate oxygen availability to support methanotrophic bacteria and drainage and moisture management to prevent oversaturation of the biofilter media.
 - Choose appropriate biofilter media based on methane oxidation capacity, durability, and availability of materials. Methane uptakes rates can be affected by moisture content, temperature, and soil properties of the biofilter material, and research shows that high oxidation capacity correlates with coarse, porous soil rich in organic matter and has increased with moisture content. The most effective media are wood chips, bark mulch, compost, and biochar. If local compost is available, for example, it will be used because of reduced costs and transportation emissions. (e.g., compost, wood chips, or biochar) based on methane oxidation capacity and durability, as well as local availability of materials. Methane uptake
- Hire local contractors to build and install the biofilter frames and fill frames with filter medium and permeable material and implement erosion control measures as needed.

Objective 3: Evaluate solar and/or battery storage on closed landfills.

- Issue a request for proposals (RFP) for solar feasibility studies
- Hire one or multiple companies to conduct solar feasibility studies.

Note – if battery storage is a viable and sensible component for one or more municipalities, a discussion of battery storage may be included in the studies.

Objective 4: Evaluate efficiency of emissions reduction

Biofilter Monitoring: measuring technology effectiveness over time.

Methane monitoring will occur monthly for the first two years after biofilter installation and an initial media replacement schedule will be created to ensure proper operating conditions, including temperature, porosity, pH balance, airflow rates, and humidity / moisture control to maximize aerobic degradation. After the first two years, monitoring will move to quarterly. All biofilters will be inspected during monthly monitoring and biofilter material will be added as necessary.

Maintenance is not anticipated to be significant, save for external factors like flooding or animal interference. Results of LFG measurements noted in assessment reports will inform any changes needed to the biofilters.

During the monitoring phase, the following methods will be used for LFG measurements:

Method 1: One or several flux chambers will be placed on top of the biofilter, depending on the sizes of the filter and flux chambers. The measurements from these flux chambers will be extrapolated out or projected to represent the total surface area of the biofilter. If there are vents close enough to each other, a flux chamber multiplexor may be used for continuous monitoring for up to 4 weeks.

Method 2: For the survey approach, instead of positioning the probe in or as close to the vent as possible, the trace gas analyzer and flow meter will be moved over the surface and sides of the biofilter in a serpentine method. For the flow meter method, HVRC will install T-fittings with caps to the connection from the biofilter to the LFG vent to ensure continued access to measure flow of LFG from the vents.

Other

- The Team will aim to eventually implement biofilters at all active landfill vents and calculate emissions reductions using data from all vents pre- and post-biofilter implementation.
- If not all vents have biofilters installed, the Team will use the initial LandGEM estimates combined with % decrease of methane concentration from biofilters at active vents to extrapolate cumulative landfill emissions decreases.

Biofilter Augmentation

Special attention will be paid to factors affecting oxidation, including temperature, moisture, and biofilter design.

- If data shows that oxidation levels have dropped at a biofilter, measures will be taken to increase oxidation. These strategies include: watering in dry climates, aeration of the soil medium, or replacement or augmentation of soil material.
- If the pH levels of the biofilter medium are found to be inhibiting oxidation, or any of the operating conditions are deemed to be improper, actions may need be taken to maximize filtration efficiency. To increase soil pH (reduce acidity), liming materials such as agricultural lime (calcium carbonate) or dolomitic lime may be applied. To decrease soil pH (increase acidity), elemental sulfur, aluminum sulfate, or organic matter like peat moss to lower alkalinity may be added.

Objective 5: Support biodiversity adjacent to landfills.

- Scope the number of native plantings requested and conditions of potential planting locations.
- Issue RFP to for the purchase, delivery and planting of native pollinator vegetation.
- Hire one or multiple companies to deliver and plant.

Objective 6: Share knowledge about reducing emissions and productive reuse of closed landfills.

Pre-Biofilter Installation

- Initial efforts will be made with partner NJIT to educate local communities and relevant groups, and to solicit feedback and input on project details, scope, benefits and co-benefits.

- All initial feedback and concerns will be documented and addressed.

During and Post-Biofilter installation

- Engagement with local communities and relevant groups to address any concerns and maximize project co-benefits for communities (e.g., pollinator habitats)
- Host workshops, webinars, and/or community meetings to explain the science behind biofilters, their role in methane reduction, and the potential for reusing closed landfills.
- In partnership with NJIT, update web site with project findings and develop informational materials such as brochures, fact sheets, or online resources to make the information easily accessible to stakeholders.
- Facilitate collaborative interactions between local governments, relevant groups, businesses, and residents to promote the benefits of biofilters and reuse options for closed landfills.
- Partner with organizations and industry experts to share findings and further explore innovations in biofilter technology and landfill reuse strategies.

A.6 Information/Data Quality Objectives and Performance/Acceptance Criteria

The data quality indicators and objectives that will be used to evaluate the data quality from this project include accuracy/bias, comparability, completeness, precision, regulatory compliance, representativeness, and sensitivity.

Accuracy/Bias. All instruments will be calibrated prior to use for field measurements. If instrumentation drifts beyond 3ppm it will be recalibrated.

Objective: All data will be routinely checked for accuracy/bias.

Comparability. The qualitative term that expresses the measure of confidence that two or more data sets can contribute to a common analysis. Before pooling data, the comparability of data sets generated at different times must be evaluated to establish whether two data sets can be considered equivalent regarding the measurement of a specific variable or groups of variables. Data will be deemed comparable only if it uses standardized sampling procedures, instrumentation, and data processing methods to maintain uniformity.

Objective: Standardized sampling and analysis methods will be used across-site landfills and measurements will be consistently collected, analyzed, and reported across all 14 sites to enable reliable comparisons.

Completeness. A measure of the amount of valid data obtained from a measurement system, expressed as a percentage of the number of valid measurements that should have been collected (i.e., measurements that were planned to be collected).

It is expected that samples will be collected from the fourteen sites participating in this project (see Appendix A) for a continuous 3-year period on a monthly basis. Data collection may be ongoing for up to a period of 4 weeks if using continuous flux chamber method is used. Project staff will be deployed to each landfill at least monthly to collect data and to capture regional ambient conditions (i.e. temperature and atmospheric pressure, PH, etc.) Because of barometric pressure variations, LFG flow can vary significantly during the year and our visits may not align perfectly to capture a full picture of annual ghg emissions.

Objective: Measurements will be collected multiple times a year during all four seasons and in differing environmental circumstances (temperature, pressure, etc.)

Precision. Precision is indicated by the measure of agreement among repeated measurements of the same property under identical, or substantially similar conditions and calculated as either the range or as the standard deviation. The two methods discussed in section A5 will be utilized to compare results across methodologies and compared to the LandGEM model.

Objective: Instruments have been chosen for their accuracy and reliability, and the field methods have been chosen to allow repeated measurements of the same property under similar conditions. All instruments used will be routinely tested for precision and be maintained according to the recommendations outlined in the operating manual.

Regulatory Compliance. Compliance is indicated by the extent to which data collection methods are EPA-approved, and periodic audits are conducted.

Objective: Ensure data meets 100% compliance for local and national environmental reporting standards and that all data is defensible for reporting, as well as regularly calibrating instruments, using EPA-approved sampling methods, and conducting periodic audits to verify data validity.

Representativeness. Defined as the measure of the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. For example, the QAM will assess the representativeness of the operating year of data selected as the baseline year by comparing data gathered to independent LandGEM estimates. The QAM will assess the representativeness of the data estimates for future years through 2050 by comparing the adjustments to baseline conditions.

Objective: Data will be deemed representative only if it truly represents characteristics of the system being measured.

Sensitivity: Sensitivity refers to the ability of the data collection and analysis system to detect small changes or variations in the data.

Objective: Sensitivity will be considered and reported according to the relevant equipment manufacturer's guidelines.

Acceptance and Performance Criteria

Acceptance and performance criteria will ensure the effectiveness, durability, and environmental compliance of the project. These criteria will guide equipment purchase, site selection, material specifications, performance benchmarks, and data quality requirements.

The baseline activity data will be collected in spreadsheets and assessment reports accessible in MS Sharepoint and in a format that allows for development of the metrics required under this task. Accordingly, comparable verification and estimates will be prepared independently by assigned staff. The primary estimates will be verified as acceptable if the initial results are within 20 percent of the primary estimates or there is insufficient causality to explain the deviation.

Objective 1: Monitor methane emissions from closed landfills

- Methane (CH₄) Emission Levels:
 - Acceptance Criteria: Determine what level of LFG emissions will justify biofilter implementation.
 - Performance Criteria: Determine the efficiency under a variety of atmospheric pressure and weather conditions.
 - Required Data: Continuous gas monitoring data (pre- and post-installation) using gas chromatography or field sensors.
- Environmental and Regulatory Compliance:
 - Acceptance Criteria: Compliance with all state and federal and state-specific regulations.

Objective 2: Install biofilters to reduce methane emissions from closed landfills

- Acceptance Criteria: Demonstrated minimum 30% CH₄ oxidation efficiency within the first year.
- Performance Criteria: Achieve and sustain 50-90% CH₄ oxidation over multiple years.
- Required Data:
 - CH₄ flux measurements at various depths using static chambers.

Objective 3: Install solar and/or battery storage on closed landfills

- Acceptance Criteria: Publish municipal RFPs for solar and/or battery storage on landfills (5 landfills initially interested in solar and 7 in battery storage).
- Performance Criteria: Up to 5 solar feasibility studies completed.

- Required Data: Only landfill site conditions will be required to produce RFP.

Objective 4: Evaluate efficiency of emissions reduction

- Acceptance Criteria: Level of degradation of biofilter material per year.
- Performance Criteria: Determine CH₄ oxidation efficiency over time and under which criteria.
- Required Data: Periodic biofilter media sampling, moisture content analysis, and microbial viability testing.

Objective 5: Support biodiversity and resilience on landfills

- Acceptance Criteria: Long-term stewardship plans created and pollinator-friendly plantings completed on landfills.
- Performance Criteria: Plants are healthy at least 1 year after planting.
- Required Data: Visual assessments of plantings at landfill sites to determine health of plantings.

Objective 6: Share knowledge about reducing emissions and productive reuse of closed landfills

- Acceptance Criteria: Educational materials developed and workshops held to engage and inform the public.
- Performance Criteria: public web site developed and at least one public workshop or event held per region.
- Required Data: Numbers of webpages and attendees at info sessions and webinars.

If environmental information operations do not adhere to regulatory requirements or fail quality assurance (QA) checks, the following actions should be taken:

Identify and Investigate Non-Compliance Issues

- Conduct an internal audit to determine the root cause of non-compliance.
- Review data collection methods, calibration records, and reporting protocols to identify inaccuracies.
- Engage third-party reviewers or experts to validate findings.

Immediate Corrective Actions

- Rectify Data Gaps: Re-collect missing or erroneous environmental data.
- Recalibrate Equipment: Ensure monitoring tools (e.g., flux chambers) are functioning correctly according to manufacturer's operating standards.
- Staff Training: Provide refresher training on QA/QC protocols for data collection and reporting.

Regulatory Compliance and Reporting

- Report non-compliance to regulatory agencies (e.g., EPA, NYS DEC) as required.
- Submit corrective action plans outlining steps to address deficiencies.
- If necessary, conduct remediation efforts (e.g., increased monitoring, improved filtration for air/water contamination).

Preventative Measures

- Implement standard operating procedures (SOPs) for data integrity.
- Schedule regular QA Manager and outside consultant audits to ensure reasonability and compliance with federal and state regulations.

A.7 Distribution List

The original Quality Assurance Project and Management Plan (QAPMP), and any subsequent revisions, will be distributed to the personnel presented in Table 1. Additionally, this QAPMP will be provided to any unlisted staff who are assigned to perform work under this project. A secured copy of this QAPMP and any subsequent revisions will be maintained in an appropriate HVRC Sharepoint folder.

Title	Name
Project Oversight	Eleanor Peck, Deputy Executive Director, Hudson Valley Regional Council, 105 Ann Street, Newburgh, NY, 12550
Interim Quality Assurance Manager	Ryan Corbett, Water Resources Manager, Hudson Valley Regional Council, 105 Ann Street, Newburgh, NY, 12550
Field Team Leader / Environmental Scientist	TBD, Hudson Valley Regional Council, 105 Ann Street, Newburgh, NY, 12550
Data Processor	Mary Lambert, Climate Action Planning Manager, Hudson Valley Regional Council, 105 Ann Street, Newburgh, NY, 12550
EPA Project Officer	Valerie Askinazi, US Environmental Protection Agency - Region 2, Air & Radiation Division Technology, Transportation & Partnerships Branch, 290 Broadway, New York, NY 10007. Office: 212-637-3890
EPA Quality Assurance Manager (QAM)	US Environmental Protection Agency Region 2, Laboratory Services & Applied Science Division, Monitoring and Assessment Branch, Quality Assurance and Technical Support Section
Project Quality Assurance Consultant	TBD
Biofilters Design Consultant	TBD
Biofilters Installation Contractor	TBD

A.8 Project Organization

Below are the roles and responsibilities for the key staff:

Approval authority for the QAPP, Deputy Executive Director having executive leadership authority, Project Manager, Project QAM.

The primary personnel responsible for implementation of this project are the Biofilters Project Manager (PM), Environmental Scientist (ES), and Quality Assurance (QA) Manager. The Project Manager is Mary Lambert. She will provide senior-level oversight as needed. The PM is responsible for the Project's technical and financial performance as well as maintaining communications with the EPA to ensure mutual understanding of grant requirements, EPA expectations, and conformity with EPA quality procedures; managing oversight and conduct of project activities including the planning of required training for technical staff; allocation of resources to specific tasks; ensuring that quality procedures are incorporated into all aspects of the project; developing, conducting, and/or overseeing QA plans as necessary; ensuring that any corrective actions are implemented; operating project activities within the documented and approved Quality Assurance Project Plan; and ensuring that all products delivered to the EPA are of specified type, quantity, and quality. The PM is responsible for developing a training plan for the Environmental Scientist, who will be conducting methane concentration and flow measurement data collection both pre- and post-biofilter construction.

The Environmental Scientist (ES) will be hired in Spring 2025. ES will perform technical tasks and is responsible for the day-to-day field work and technical activities under their assigned task, including planning, reporting, and controlling of technical resources allocated to the task by the PM. Accordingly, the ES is primarily responsible for implementing the Quality Program and this QAPMP on task-level assignments. For each major deliverable under each task, the ES will review all QA-related plans and reports and is responsible for transmitting them to the QA Manager (or delegate) for review and approval. The ES is responsible for ensuring that quality procedures are implemented at the task level and for maintaining the official, approved, task-level QAPMP content. The ES will discuss any concerns about quality or any proposed revisions to task-level QAPMP content with the QA Manager (or delegate) to identify, resolve, or preclude problems or to amend task-level plans, if necessary. In addition, The ES will work with the PM and the QA Manager to identify and implement quality improvements. The PM is responsible for ensuring the consistency of similar or related QA measures across tasks, and the ES is responsible for providing assurance that all required QA/QC procedures are being implemented.

Tasks are expected to proceed concurrently, in parallel. The PM will maintain close communication with the ES and ensure any difficulties encountered or proposed changes at the task level are reviewed for implications on other similar or related tasks. The PM is also responsible for communicating progress or difficulties encountered (across all tasks) to the EPA PO, who provides the EPA's primary oversight function for this project at EPA Region 2 and is responsible for review and approval of this QAPMP and any future revisions. The PM (with support from the ES and consultants) will be responsible for consulting with the EPA PO, on planning, scheduling, and implementing the QA/QC for all project deliverables and obtaining required EPA approvals.

The QA Manager role is discussed in Section A.9.

A.9 Project QAM Independence

The Quality Assurance Manager (QAM). HVRC's Water Resources Manager, Ryan Corbett, will serve as the interim QAM until the biofilters consultant is hired, at which point QAM responsibilities will be turned over to the consultant. The

QAM will work independently of the PM, ES, and all project contractors and consultants. The QAM is responsible for ensuring data accuracy, consistency, and compliance with regulatory and project standards. This includes overseeing sampling protocols, calibration of monitoring equipment (e.g., LI-7810 analyzer), data validation, documentation, and reporting, while also implementing corrective actions to maintain high data quality and project integrity. Ryan has experience in QA from his time as a Geologist for multiple engineering companies and as a Production Manager and Brewer at various breweries.

HVRC will follow a structured procurement process to select consultants and contractors for the LFG calculations, biofilter design, biofilter installation, and pollinator plantings. These processes will involve a Requests for Proposal (RFPs), competitive bidding, qualifications-based selection, and contracting based on project needs and funding requirements. HVRC has developed the following high-level evaluation criteria for each selection:

1. Consultant for LFG Calculations

- **Selection Process:** RFP for a landfill and emissions expert
- **Evaluation Criteria:**
 - Experience with LFG emissions modeling and gas composition analysis
 - Familiarity with regulatory compliance for LFG management
 - Interest in innovative ideas to reduce methane emissions from closed landfills
 - Previous experience with similar landfill projects
 - Cost-effectiveness and technical approach

2. Contractor for Biofilter Design

- **Selection Process:** RFP for a specialized biofilter design firm
- **Evaluation Criteria:**
 - Experience designing biofilters for landfills
 - Knowledge of optimal media selection and performance modeling
 - Engineering expertise in LFG
 - Ability to integrate site-specific constraints

3. Contractor for Biofilter Installation

- **Selection Process:** RFP for one or more firms specialized in construction of biofilter-like structures
- **Evaluation Criteria:**
 - Construction experience for biofiltration systems or similar construction projects
 - Ability to work within landfill operational constraints
 - Cost, timeline, and track record with environmental compliance

- Availability of local specialized equipment and skilled labor

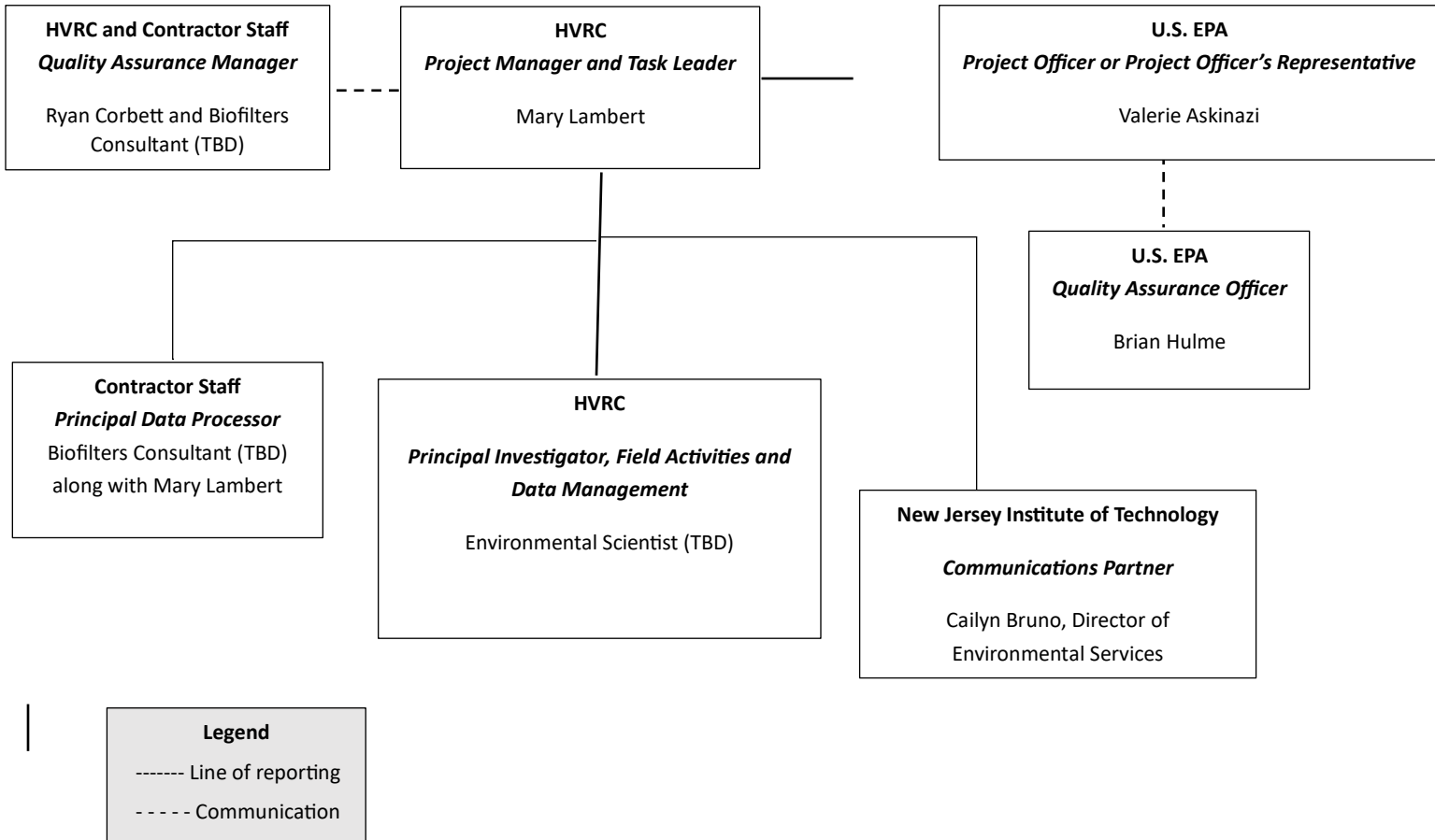
4. Consultant for Pollinator Plantings

- **Selection Process:** RFP for one or more firms specialized in native pollinator plantings
- **Evaluation Criteria:**
 - Expertise in pollinator-friendly landscaping and native plant selection
 - Understanding of soil conditions and ecological restoration
 - Ability to create a sustainable, low-maintenance planting plan
 - Ideal: experience working on landfill or brownfield revegetation projects

A.10 Project Organizational Chart and Communications

See below for the organizational chart depicting lines of authority and reporting responsibilities.

Figure 1. Template Organization Chart¹



A.11 Personnel Training/Certification

The ES, as well as any subsequent field personnel hired for the project, will be trained in field and laboratory measurements, instruments calibration, and analysis activities, as well as all necessary safety training. Applicable Records will be kept in HVRC's Sharepoint folders and a record of training activities will be kept on file and may be reviewed by EPA. PM is responsible for ensuring personnel have appropriate training and for documenting appropriate training.

Applicable safety trainings:

- OSHA 40-Hour HAZWOPER (Hazardous Waste Operations & Emergency Response)
- OSHA Respiratory Protection (29 CFR 1910.134) – Necessary if personnel may be exposed to LFGs such as methane (CH₄), hydrogen sulfide (H₂S), or volatile organic compounds (VOCs).
- OSHA General Industry Safety (OSHA 29 CFR 1910) – Covers overall workplace safety, including personal protective equipment (PPE), hazard communication, and emergency response.
- Licor Gas Detection & Monitoring Equipment Training – Hands-on training for using the LI-7810 analyzer, multiplexer, and other LFG monitoring tools.

A.12 Documentation and Records

Standard Operating Procedures (SOP) documents for installation, set up, calibration, and operation of the instruments will be created prior to commencement of field operations.

A field logbook will be filled out using permanent waterproof ink for the records of lab calibration, maintenance, monthly site check, mobile lab field measurements, and all other related items. The logbook will be scanned every month to be saved in the mobile workstation and the online cloud storage (i.e., MS Sharepoint). Any procedural or equipment problems will be recorded along with data results in the logbook.

Any measured raw data will be uploaded to the Cloud with link shared with EPA PO. The raw data will be copied every one month when doing field maintenance.

Records of internal meetings, and meetings with the communities/local agencies/EPA will also be kept and included in reporting to distribution list.

The code/procedures for analyzing the data will be saved and stored on the online cloud storage and sent to the distribution list.

The produced semi-annual/final reports will be saved and stored on the online cloud storage and sent to the distribution lists. The project progress, planned progress in the future, identified problems with planned solutions, the ability to meet schedule, the analysis of actual cost incurred in relation to the budget, etc. will be included in reports. The variations, the methane and CO₂E estimates, methane/pollutant source identification, will be included in the annual/final report.

The presentations/manuscripts made during and after the project will be saved and stored on the mobile workstation and the online cloud storage and sent to the distribution list.

All records will be retained for a minimum of 5 years after the end of the project in 2029.

Section B: Implementing Environmental Information Operations

B.1 Identification of Project Environmental Information Operations

The following describes the primary EIOs that will be conducted by task.

Task 1. Collection of Baseline Activity Data for Estimating Reductions in Environmental Impacts. This task will be completed within 12 months of the approval of this QAPMP.

Under Task 1, the Environmental Scientist (ES) will collect information delineated in **Exhibits 1.1**

Exhibit 1.1 The following data will be collected and compiled from each landfill			
Location Identification	Landfill Characterization	Temporal, Atmospheric & Geospatial Parameters	LFG Concentrations
Landfill Name County Address Main contact	Number of vents Height of vents Type of vents Avg estimated distance between vents Piping system Structural integrity and operational status of vents	Topography Season Month Wind observations Barometric Pressure Other weather data Plantings along border Soil type Nearby structures Nearby ecosystems	Methane Carbon Dioxide Oxygen VOCs Pressure

Task 2. Conversion and analysis of baseline data. This task will be completed within 12 months of the approval of this QAPMP.

Under Task 2, the Environmental Scientist (ES) will collect information delineated in **Exhibit 2.1**

Exhibit 2.1 The following data will be compiled from each landfill	
Landfill Name County Address	Calculations of landfill emissions based on collected data projected out to 2030. Updated estimates of emissions using the EPA LandGEM tool. Comparisons and analysis of results between methods.

Task 3. Projections of emissions reductions (MT CO₂e) through 2030 and 2050 using collected data. This task will be completed within 24 months of the approval of this QAPMP.

Under Task 3, Environmental Scientist (ES) will collect information delineated in **Exhibit 3.1**

Exhibit 3.1 The following data will be compiled from each landfill

Landfill Name County Address	Comparisons of results between 2 methods to data estimates from the EPA's LandGEM tool. Calculation of emissions and % of methane abated by the project through 2030 and 2050, based on the delta between the baseline and post-biofilter implementation methane concentrations.
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B.2 Methods for Environmental Information Acquisition

All primary data gathered / data collected for this project will be reviewed by at least 2 staff (or consultants) to assess data quality and completeness. For non-direct data usage, original sources for all information and data are included with references and appropriate citations.

The ES will document information regarding each dataset and the rationale/selection criteria for selecting the data sources used. The ES will be responsible for overseeing and confirming the selection of the data for the project tasks. See Section D.2 for further information on data usability.

Standard Operating Procedures (SOP) documents will be created before any field measurements occur. While the Team may deem it necessary to modify the list of SOPs, below is an initial list of project SOP documents:

SOP Number	Title	Version/Revision Date	Revision #
SOP-ENV-001	Site Feasibility Assessment	2/15/2025	Rev. 1.1
SOP-ENV-002	Landfill Gas Sampling & Analysis	4/1/2025	Rev. 1.1
SOP-ENV-003	Emission Rate Measurement Protocols	4/1/2025	Rev. 1.1
SOP-ENV-004	Biofilter Design & Installation Guidelines	6/1/2026	Rev. 1.1
SOP-ENV-005	Regulatory Compliance & Reporting	4/1/2025	Rev. 1.1
SOP-ENV-006	Stakeholder Engagement & Public Communication	6/1/2025	Rev. 1.1
SOP-ENV-007	Continuous Monitoring & Performance Evaluation	6/1/2026	Rev. 1.1
SOP-ENV-008	Data Management & Quality Assurance	3/15/2025	Rev. 1.1

All information obtained from databases or websites will be properly cited and identified in bibliography. There will not be any laboratory analyses associated with this project.

For more information, see [Region 2 Quality Assurance Guidance and Standard Operating Procedures](#).

B.3 Integrity of Environmental Information

As this project is measuring in-time ambient measurements, no special sample handling and custody procedures are needed.

B.4 Quality Control

Quality Control activities are fully integrated into the project. We will produce the Standard Operating Procedures (SOP) for the set up and operation of all instruments and working with the data output. Before the first field campaign and the end of the final field campaign, all instruments will be calibrated in the use of calibration gases, and calibrated results will be recorded in the field notebook and in calibration sheets on a laptop.

Every month, the ES will save all the raw data, the scanned notebook, and the record sheets to the online cloud storage, with link shared with EPA project manager. Additionally, the ES and PM together will produce data packages for reporting purposes – suitable for delivery to EPA or other appropriate data archive locations and will ensure that EPA is aware of the data sets collected.

Quality Assurance (QA) Measures

By applying responsible QA measures, biofilters can be optimized for maximum methane reduction, regulatory compliance, and environmental benefits while ensuring long-term functionality and data integrity.

1. Methane Monitoring
2. Data Quality Assurance & Control (QA/QC) Procedures
 - a. Define protocols for gas sampling, flux chamber measurements, and data logging to ensure accuracy and consistency.
 - b. Establish calibration procedures for gas analyzers and other monitoring equipment.
 - c. Implement duplicate sampling and cross-verification
 - d. Practice good maintenance of all equipment and tools
3. Risk Assessment & Mitigation Planning
 - a. Identify potential risks (e.g., inaccurate vent mapping, equipment malfunctions, or unexpected landfill conditions).
 - b. Develop contingency plans for weather disruptions or seasonal variability in gas emissions.
4. Regulatory & Permitting Compliance Documentation
 - a. Specify a compliance checklist for NYS DEC and EPA regulations.
 - b. Outline a schedule for Plan reviews, review timelines, and agency coordination.
5. Stakeholder & Community Engagement
 - a. Define methods for outreach (e.g., public meetings, surveys, or digital engagement).
 - b. Develop a feedback integration plan to incorporate community concerns into the project.
6. Project Timeline & Milestones
 - a. Create a detailed work schedule with QA checkpoints to track assessment progress.
 - b. Identify key milestones for data collection, validation, and reporting.
7. Resource Allocation & Personnel Training
 - a. Ensure all staff are trained in QA/QC procedures, safety protocols, and regulatory compliance.
 - b. Define personnel roles for data collection, analysis, and reporting.
8. Biofilter Media Testing & Maintenance:

- a. Regularly (every 4-6 weeks) test biofilter moisture content, pH levels, and microbial activity to ensure biofilter efficiency.
 - b. Replace or replenish biofilter media as it degrades.
 - c. Optimize air distribution to prevent channeling or short-circuiting of LFG.
9. Long-Term Performance Evaluation:
 - a. Implement a multi-year monitoring plan to assess methane oxidation rates and make adjustments as needed.
 - b. Compare measured methane reduction with projected estimates calculated using the EPA's LandGEM tool to determine effectiveness.
 - c. Document findings and share data for continuous improvement in landfill methane mitigation strategies.

B.5 Instrument/Equipment Calibration, Testing, Inspection, and Maintenance

HVRC will purchase calibration gas to calibrate Licor 7810 gas analyzer instrument. We will follow manufacturer directions for calibration, including using zero gas (nitrogen and oxygen) as well as span gas for the highest concentration we expect to see (e.g. 75ppm methane) When the machine drifts out of the expected range, we will zero it out again to shift the calibration curve to read accurately. HVRC plans to purchase a 5-year service agreement so the equipment will be under warranty for the full grant term. Licor will provide a loaner instrument if our equipment needs to be returned to Licor to be serviced under the agreement. Licor will replace spare parts as needed.

B.6 Inspection/Acceptance of Supplies and Services

This project requires supplies for the collection and analysis of samples. The project also includes services provided by contractors and consultants for gathering and analyzing environmental data. The PM maintains contractor oversight for the life of this project. Contractor services will be reviewed as outlined in the Statement of Work. Under this project, HVRC's existing quality management systems will be utilized such that task-level deliverables will be subjected to required, regular reviews (e.g., quarterly) to ensure that technical, financial, and schedule requirements of this project are consistent with the expectations for handling and producing deliverables that reflect high-quality environment data as required by this QAPP. Assessment and oversight are discussed further in Sections C.1 and C.2, respectively.

The project PM will be responsible for inspection and/or acceptance of all related products and services.

B.7 Environmental Information Management

Quality Assurance/Quality Control (QA/QC) of data management will begin with the raw data and will end with a publicly available report. Data management encompasses and traces the path of the data from their source to their final use or storage and includes the control mechanism for detecting and correcting errors. Data management procedures also include file storage and file transfer. All project and data files will be stored on HVRC project servers. Files will be organized and maintained by the PM in folders by project, task, and function, including a system of file labeling to ensure version control. The PM will make sure that staff is briefed on and adhere to the project file organization and version control labeling to ensure that files are placed in consistent locations. The project server automatically backs up all files each night to avoid loss of data. Data are stored in various formats that correspond to the software being used. As necessary, data will be transferred using various techniques, including email, File Transfer Protocol, or shared drives. Section A.12 provides the record retention timeframe for files generated under this project.

HVRC has developed a file naming convention/nomenclature for electronic file tracking and record keeping. Foremost, all files must be given a short but descriptive name. For those records and files gathered or provided HVRC, the filename may include the identification of “original” in its filename. Similarly, files that have undergone a review by an independent, qualified person will include, at the end of the filename, the initials of the reviewer(s) along with the date reviewed and version number, to track which staff person(s) reviewed the file and when. For each successive draft of a document, the version is numbered sequentially (e.g., v1, v2, v3) until a final version is complete. The final version will have the highest version number and most recent date. In the event data retrieval is requested and to prevent loss of data, all draft and final file versions will be retained electronically - that is, superseded versions will not be deleted.

Note that changes made to deliverables will be documented using the software’s track changes feature, which allows a user to track and view all changes that are made to the document version. All deliverable reviews will be documented in a standard QC Documentation Form (see Appendix E) for the project. This form will be maintained in the project files.

Section C: Elements for Assessment, Response Actions and Oversight

C.1 Assessments and Response Actions

The QA program includes periodic review of data files and all draft deliverables. The essential steps in the QA program are as follows:

1. Identify and define the problem
2. Assign responsibility for investigating the problem
3. Investigate and determine the cause of the problem
4. Assign and accept responsibility for implementing appropriate corrective actions
5. Establish the effectiveness of and implement the corrective action
6. Verify that the corrective action has eliminated the problem.

The PM will provide day-to-day oversight of the quality system for their task. Periodic project file reviews will be carried out by the QAM at least once per year to verify that required records, documentation, and technical review information are maintained in the files. The QAM will ensure that problems found during the review are brought to the attention of the applicable Task Leader (TL) and are corrected immediately. All nonconforming data will be noted, and corrective measures to bring nonconforming data into conformance will be recorded.

The PM and QAM are responsible for determining if the quality system established for the project is appropriate and functioning in a manner that ensures the integrity of all work products. All technical staff have roles and will participate in the corrective action process. Corrective actions for errors found during QC checks will be determined by the PM and, if necessary, with direction from the QAM or PM, as appropriate. The originator of the work will make the corrections and will note on the QC form that the errors were corrected. A reviewer not involved in the creation of the work, will review the corrections to ensure the errors were corrected. Any problems noted during audits will be reviewed and corrected by the QAM and discussed with the PM as needed. Depending on the severity of the deficiency, the PM may consult the QAM and stop work until the cited deficiency is resolved. The QAM will produce an assessment report outlining any issues discovered and the corrective actions taken. The assessment reports will be provided to the PM, as applicable. The QAM and PM will comply and respond to all internal and EPA audits on the project, as needed. The QC forms, assessment reports, and periodic reports will be maintained in project files.

C.2 Oversight and Reports to Management

After completion of each of the following milestones in the project, the QAM is responsible for preparing a report for the PM summarizing the initial findings by the QC team, response actions by the PTT, implications for subsequent tasks, and any recommendations for revising this QAPP:

1. The initial training and certification of the PTT and QC team members under A.11.
2. The compilation of work products under Task 1.
3. The compilation of work products under Task 2.
4. The compilation of work products under Task 3.

Additionally, periodic progress reports (to the EPA PO) required in the grant agreement will describe the status of the project, accomplishments during the reporting period, activities planned for the next period, and any special problems or events including any QA/QC issues. Reports to the EPA will be drafted by the PM or other project staff familiar with

project activities during the reporting period. These periodic progress reports will be reviewed by the PM to ensure the project is meeting milestones and that the resources committed to the project are sufficient to meet project objectives.

QC issues impacting the quality of a deliverable, the project budget, or schedule will be identified and promptly discussed with the assigned TL and the PM or QAM as appropriate. Significant findings will be included in the periodic reports with the methods used to resolve the specific QC issue or the recommendations for resolution for consideration by the EPA PO or designee.

Based on the technical work completed during the reporting period, progress reports will be reviewed internally by an independent, qualified technical person (equivalent or senior to the TL), prior to submitting to the PM. The PM will conduct a final review of the report before transmitting the progress report to the EPA PO.

Reports, such as the milestone QC reports and grant progress reports, are maintained in project files.

Section D: Elements for Environmental Information Review and Usability Determination

D.1 Environmental Information Review

As a standard operating procedure, the PM is responsible for ensuring all data (retrieved or generated) for this project will be submitted to the QAM for verification, validation, and data quality assessments (as differentiated below with the definitions of these terms). The following types of reviews will be conducted by person (or persons) not directly involved in the production of the primary deliverables.

- **Data verification** to evaluate the completeness, correctness, and conformance/ compliance of data sets against the method, procedural, and contractual requirements.
- **Data validation**, a sample-specific process to extend the evaluation of data beyond verification to determine the analytical quality of specific data sets.
- **Data quality assessment (DQA)** to determine if data obtained from EIOs are of the right type, quality, and quantity to support intended use.

Work conducted under this project by the ES will be subject to technical and editorial review, first by the PM followed by independent QAM staff and/or consultants. When existing data for the same activity are available from multiple sources, the background information documents will be reviewed for all sources to determine the dataset that is the most representative of operations in the domain and the PM and QAM will determine which data set(s) should be used for the primary estimates and which should be used for quality control measures. Additionally, preference will be given to the most recent dataset that is representative of similar activities in the domain.

In addition to the quality assurance measures implemented by the ES, the quality of data used and generated for the project will be formally verified and documented by the QAM when the ES submits each draft deliverable to the QAM. The QAM is responsible for verifying both the original draft and any modified files prepared by the ES in response to QAM findings. Both original and modified data files will be verified for input, handling, and calculation errors. Additionally, units of measure will be checked for consistency. Potential issues identified through this review process will be evaluated and, if necessary, data will be corrected, and analysis will be revised as necessary, using corrected data. These verification activities will be documented in project records.

Typical data verification reviews may include checks of the following:

- Data sources are clearly documented
- Calculations are appropriately documented
- All relevant assumptions are clearly documented
- Conclusions are relevant and supported by results
- Text is well-written and easy to understand

The documented review process will be stored with deliverables for the project.

QC objectives include verification that data in database tables are stored and transferred correctly, algorithms call data correctly, units are internally consistent, and reports pull the required data. These data management measures will be addressed as part of the QC checks of data acquisition and document preparation.

An initial checklist of QC activities for deliverables under this project is provided in Appendix E. Checklist is subject to modification. Documentation of calculations to support verification will be included in spreadsheet work products and in supporting memoranda, as appropriate.

After completion of verification of the primary calculations by the PM and the QAM, emissions estimates will be validated for conformance with A.6 acceptance criteria using independent calculations as directed by the QAM.

For this project, it is not anticipated that any special data validation software will be required. However, where calculations are required to assess the data/datasets, calculations will be performed using computer spreadsheets (like Excel spreadsheets with predefined functions, or formulas) and calculators to reduce typographical or translation errors. General software available through the Microsoft Suite including Excel, PowerPoint, Access, and Word will be sufficient to perform the work as described in Section A5.

The QAM is also responsible for rendering the final DQA of the EIOs under this project that characterize the baseline environmental benefits and benefits through 2050. The QC team will compare the verified and validated emission factors under this project versus factors published by an independent source that includes data for the same geographic domain or for a super domain that includes the project domain. The QC team shall document reviews and note any significant deviations between the primary team's estimates and the observed degradation of similar existing units. The QAMs DQA report shall clearly state whether or not the QC team has determined that the primary estimates are of the right type, quality, and quantity to support the intended use under this project.

The QAM will prepare a formal report of the findings for each cycle of primary work followed by formal independent review. The PM will review each DQA report with the QAM, and the EPA PO (as directed) to ensure the PTT understands the QAMs findings and to ensure the planned corrective actions are fundamentally sound and will meet the project objectives. All documentation developed by the TL to resolve DQA Report findings will be maintained in project files and made available to the QAM for final resolution of findings.

D.2 Usability Determination

Determining useability of the environmental information is the culmination of the entire QA process for the project and involves a retrospective evaluation of the planning process. Not all environmental information may be useable for its intended purpose. The useability of the environmental information is performed at the conclusion of the environmental information operations using the outputs of the environmental information/data verification, the environmental information/data validation, and the environmental information/data quality assessment activities.

This reconciliation phase involves a qualitative and quantitative evaluation of environmental information to determine if the project information is of the right type, quality, and quantity to support its intended use. **Table 2** below presents an example hierarchy for data quality when identifying and reviewing available sources of data and information. The source types in the table appear in the order in which they are likely to meet the data quality criteria. When evaluating data resources, efforts will be made to identify and select data sources that most closely conform to the highest ranked criteria.

Data quality metrics and documentation may not be provided by each source, and as necessary, the TLs may consult with subject matter experts from permitted facilities or trade associations to qualify data for use to meet project objectives.

Any available data quality information will be reviewed by the applicable TL to ensure that the data represent full-scale designs and commercial processes, and that they are applicable to economic and regulatory conditions in the United

States. The TLs will document data sources used and any significant limitations of utilized data or information to ensure that the data are appropriate for their intended use. An internal technical reviewer will review the approach for selecting and compiling data; the review will include examination of the data sources and the intended use of the data. The specific QC techniques used will depend on the technical activity or analysis to which they are applied. The TL is responsible for verifying the usability of data and related information. Not all environmental information will ultimately be useable. All documentation developed by the TL for the usability determinations will be maintained in project files.

Table 2. Existing Data Quality Ranking Hierarchy

Quality Rank	Source Type
Highest	Federal, state, local and/or tribal government agencies
Second	Consultant reports for state and local government agencies
Third	NGO studies; peer-reviewed journal articles; trade journal articles; conference proceedings
Fourth	Conference proceedings and other trade literature: non-peer-reviewed
Fifth	Individual estimates (e.g., via personal communication with vendors)

HVRC will work with EPA to ensure that all data used for the project is appropriate for its intended use. The main criteria that will be used in the selection of the data are the quality of the data (based on peer review, credible source, and/or QA documentation), availability, and suitability for the intended purpose.

These measures of data quality will be used to judge if the data is acceptable for their intended use. In cases where available data do not or may not meet data quality acceptance criteria, the TL will document a discussion for review and approval by the PM and QAM explaining how outcomes that relied on such data compare to estimates. We will also consider, for example, the age (i.e., date of the source dataset) and the representativeness of the data and will include in the outcomes report for review and approval by the PM and QAM any quality concerns or uncertainties introduced with use of these data, such as data gaps or inconsistencies with other sources. Any data source utilized that is older than 10 years will specifically be flagged in the outcomes report.

Representativeness will be evaluated by determining that the emissions or activity data are descriptive of conditions in the United States, that the data are current, and that the data are descriptive of similar processes within the domain. Any incomplete datasets will be identified, and deficiencies will be evaluated to determine if data are missing or confusing and if they meet quality objectives.

Key screening criteria will be used to screen the sources identified. The TL will provide oversight to the screening process to ensure sources collected are the most relevant and meet quality requirements. Available data and information from the selected sources will be compiled and relevant summary information will be extracted from the information sources to develop the required output for each of the project tasks. As noted above, documentation developed by the TL for the usability determinations will be maintained in project files.

Appendix A: Input from LandGEM for Fourteen Participating Municipal Landfills, Baseline year 2019

Table 2 from [HVRC's Technical Addendum](#) to the HVRC Landfill Biofilters Project application. Data on participating landfills and estimated GHG emissions.

Table 2. Inputs for LandGEM, Baseline Year 2019

Landfill	Lbs./person/day	lbs./person/year	Population ¹⁴	Tons of waste/Year	Total Waste in Place (Tons)	Methane (metric tons)	Total Landfill Emissions (MTCO ₂ e)
Amenia Town Landfill	5.15	1,879.75	7,433	6,340	234,589	68	2,242
Town of Bethel Landfill	4.6	1,679	2,450	1,866	76,501	25	700
Beacon City Landfill	4.6	1,679	13,110	9,984	369,421	73	2,044
Cornwall Town Landfill	5.15	1,879.75	6,857	5,847	239,709	68	1,904
Dutchess County Landfill	4.6	1,679	95,904	73,039	365,194	167	4,676
Town of Gardiner Landfill	4.6	1,679	2,675	2,037	83,527	53	1,484
Town of Hurley Landfill	5.15	1,879.75	6,189	5,277	237,465	136	3,808
Mamaroneck Taylor's Lane	4.6	1,679	16,345	12,448	261,408	76	2,128
New Paltz Landfill	5.15	1,879.75	5,176 ¹⁵	4,413	136,811	132	3,696
North East Town Landfill	5.15	1,879.75	2,842	2,423	65,427	44	1,232
Philipstown Landfill	5.15	1,879.75	8,705	7,422	230,090	222	6,216
Rhinebeck Town Landfill	5.15	1,879.75	6,223	5,306	158,596	112	3,136
Wallkill Town Landfill	4.6	1,679	18,338	13,966	418,977	338	9,464
Woodstock Town Landfill	5.15	1,879.75	6,276	5,351	165,886	138	3,864

Appendix B: Glossary of Terms

- **Aerobic Degradation** – The breakdown of organic compounds by microorganisms in the presence of oxygen.
- **Airflow Rate** – The volume of air passing through the biofilter per unit of time, typically measured in cubic meters per hour (m³/h).
- **Assessment Report** – A document summarizing the site evaluation, feasibility, and performance analysis of biofilters.
- **Biofilter** – A biological system that uses microorganisms to degrade pollutants in air emissions.
- **Biofilter Media** – A biological system that uses microorganisms to degrade pollutants in air emissions.
- **Biogas** – A mixture of gases, primarily methane (CH₄) and carbon dioxide (CO₂), produced from anaerobic decomposition.
- **Carbon Dioxide (CO₂)** – A common landfill gas and byproduct of microbial respiration in biofilters.
- **Climate Leadership and Community Protection Act (CLCPA)** – A climate law enacted by New York State in 2019 setting targets to reduce GHG emissions 40% (from 1990 levels) by 2030 and 85% by 2050.
- **Compost Media** – Organic material used in biofilters to support microbial communities and provide adsorption capacity.
- **Concentration (ppm, mg/m³)** – The amount of a specific gas present in the air, measured in parts per million (ppm) or milligrams per cubic meter (mg/m³).
- **Differential Pressure** – The pressure difference between the inlet and outlet of the biofilter, indicating resistance to airflow.
- **Dynamic Flow Conditions** – Variations in air or gas flow rates affecting biofilter performance.
- **Emission Rate** – The quantity of pollutants released per unit of time, typically expressed as kg/hr or mg/m²/s.
- **Environmental Compliance** – Adherence to local, national, and international regulations governing air emissions.
- **Filtration Efficiency** – The effectiveness of the biofilter in capturing and degrading airborne contaminants and GHG emissions.
- **Flux** - the rate at which gases (such as methane, carbon dioxide, or other volatile compounds) escape or flow from the landfill surface into the atmosphere.
- **Gas Flow Meter** – An instrument used to measure the rate of gas movement.
- **Gas Sampling Port** – A designated point for collecting gas samples for analysis.
- **Infrared radiation (IR)** - a type of electromagnetic radiation with wavelengths longer than visible light but shorter than microwaves (approximately 700 nm to 1 mm), which is commonly associated with heat energy, as objects emit IR based on their temperature.
- **Landfill Gas (LFG)** – A mixture of gases, mainly methane (CH₄) and carbon dioxide (CO₂), generated from waste decomposition.
- **Methanotrophs** - a specialized group of bacteria that consume methane (CH₄) as their primary energy and carbon source.
- **Nitrogen Oxides (NO_x)** – Air pollutants that may be treated using biofilters in some applications.
- **pH Balance** – The acidity or alkalinity of the biofilter media, crucial for microbial stability.
- **Porosity** – The measure of void spaces in biofilter media that affects airflow and microbial growth.

- Project Technical Team (PTT) - The team working on the biofilters project, including HVRC and EPA staff, as well as consultants and contractors.
- Runoff Management – Strategies to prevent excess water from affecting biofilter performance.
- Saturation Point – The maximum moisture content biofilter media can hold before becoming ineffective.
- Temperature Control – Maintaining optimal temperature ranges for microbial activity in biofilters.
- Ventilation Rate – The speed at which air is moved through the biofilter to maintain efficiency.
- Volatile Organic Compounds (VOCs) – Airborne pollutants that biofilters are designed to capture and degrade.

Appendix C: Project Workplan

Objective	Task	Deliverable/Milestone	Y1/ Q1	Y1/ Q2	Y1/ Q3	Y1/ Q4	Y2/ Q1	Y2/ Q2	Y2/ Q3	Y2/ Q4	Y3/ Q1	Y3/ Q2	Y3/ Q3	Y3/ Q4	Y4/ Q1	Y4/ Q2	Y4/ Q3	Y4/ Q4	Y5/ Q1	Y5/ Q2	Y5/ Q3	Y5/ Q4
.1 Research	0.11 Data and Quality Control	.111 Research techniques to effectively measure LF emissions																				
		0.112 Analyze equipment, project requirements, equipment needs and options																				
		.113 Research methods for quality control and management for equipment selected																				
		0.211 Site visits to evaluate basic landfill conditions																				
0.2 Regulatory Compliance	0.21 File necessary paperwork	0.212 Review of NY State post-closure monitoring and maintenance plans																				
		.213 Draft and approve 14 plan appendices																				
		.111 Initial kick-off calls with all stakeholders to explain project and confirm participation.																				
.3 Stakeholder Engagement	.22 Meet with and educate key project participants	.111 Meet with key stakeholders (landfill operators and managers, as well as municipal staff and elected officials) at 14 landfills																				
		1.1.1 Secure monitoring equipment and learn to use it.																				
1. Monitor methane emissions from closed landfills.	1.1 Inventorying and identify vents producing the most methane	1.1.2 Phase 1: Take baseline readings from first phase landfills																				
		1.1.3 Compare LandGEM estimates to baseline readings for first phase landfills.																				
		1.1.4 Phase 2: Get baseline readings from all landfills																				
		1.1.5 Compare LandGEM estimates to baseline readings for all landfills.																				
		1.2.1 Phase 1: Once biofilters installed, monitor emissions monthly at pilot landfills																				
	1.2 Monitor emissions monthly	1.2.2. Phase 2: Once biofilters installed, monitor emissions monthly at all landfills.																				
2. Install biofilters to reduce methane emissions from closed landfills	2.1 Secure land-use change approvals for all landfills	2.1.1 Work with DEC to complete land-use change and site management plan updates for each landfill																				
	2.2 Hire engineering, construction, and data emissions experts consultants	2.2.1 Draft RFP for consultant services following EPA and HVRC procurement standards.																				
		2.2.2 Disseminate RFP.																				
		2.2.3 Organize selection committee and review bids																				
		2.2.4 Pick consultant, finalize contract that meets EPA and HVRC procurement standards.																				
	2.3 Construct biofilters	2.3.1 Phase 1: Design biofilters based on baseline monitoring of pilot landfills																				
		2.3.2 Phase 1: Install biofilters on pilot landfills																				
		2.3.3. Phase 2: Design biofilters based on baseline monitoring of all landfills, adjusting as needed from lessons learned in pilot landfill projects.																				
		2.3.4 Phase 2: Install biofilters on all landfills adjusting as needed from lessons learned in pilot landfill projects.																				
		2.4.1 All biofilters checked during monthly monitoring, material added if necessary.																				
3. Install solar and/or battery storage on closed landfills.	3.1 Determine feasibility of solar for landfills that do not yet have it but want it.	3.1.1 Create RFP for feasibility analysis of solar/storage on landfills.																				
		3.1.2 Publish RFP broadly to vendors.																				
		3.1.3 Organize selection committee and review bids.																				
		3.1.4 Pick consultant, finalize contract that meets municipal goals and procurement standards.																				

Appendix D: Standard QC Documentation Form

Landfill Biofilters Project Quality Control (QC) Documentation Form

1. General Project Information

- **Project Name:** _____
 - **Landfill Site Location:** _____
 - **Date of Inspection:** ____ / ____ / ____
 - **QC Inspector Name & Title:** _____
 - **Weather Conditions:** _____
 - Temperature: _____ °C/°F
 - Wind Speed/Direction: _____
 - Precipitation: _____
-

2. Sampling & Monitoring Data

- **Sample ID & Location Coordinates:** _____
 - **Date & Time of Sampling:** _____
 - **Instrument Used:** (e.g., LI-7810 Analyzer, Gas Flow Meter) _____
 - **Calibration Log:**
 - Pre-Sampling Calibration: ☒ Yes / ☒ No
 - Post-Sampling Calibration: ☒ Yes / ☒ No
 - **Gas Composition Data:**
 - Methane (CH₄): _____ %
 - Carbon Dioxide (CO₂): _____ %
 - Oxygen (O₂): _____ %
 - **Flow Rate & Pressure Measurements:** _____
-

3. Biofilter Performance Parameters

- **Biofilter Media Condition:** ☒ Good / ☒ Needs Maintenance
 - **Moisture Level:** ☒ Optimal / ☒ Dry / ☒ Excessive
 - **pH Reading:** _____
 - **Temperature:** _____ °C/°F
 - **Methane Oxidation Efficiency:** _____ % CH₄ Reduction
 - **Filter Bed Porosity & Settling Issues:** ☒ None / ☒ Observed (describe below)
-

4. Quality Control Checks

- **Duplicate Sampling & Cross-Validation Results:** ☒ Pass / ☒ Fail
 - **Instrument Calibration & Maintenance Log Updated:** ☒ Yes / ☒ No
 - **Adherence to Sampling Protocols:** ☒ Yes / ☒ No (describe below)
 - **Any QC Deviations or Corrective Actions Taken:** _____
-

5. Compliance & Safety Checks

- **Compliance with Regulatory Limits:** ☒ Yes / ☒ No (details below)
 - **Safety Issues Identified:** ☒ None / ☒ Observed (describe below)
 - **PPE Usage Verified:** ☒ Yes / ☒ No
 - **Confined Space Entry Log Completed (if applicable):** ☒ Yes / ☒ No
-

6. Corrective Actions & Recommendations

- **Actions Taken to Address QC Issues:** _____
 - **Recommendations for System Adjustments:** _____
 - **Follow-up Inspection Required?** ☒ Yes / ☒ No
-

7. Signatures & Approval

- **QC Inspector Signature:** _____
- **Date:** ____ / ____ / ____
- **Project Manager/QA Manager Review & Approval:** _____

- **Date:** ____ / ____ / ____

Appendix E: QC Measures

1. General Document Quality Control

✓ **Formatting & Consistency**

- Standardized templates, font, margins, and headings
- Consistent units and date formats
- Clear legends and labels on figures, graphs, and tables

✓ **Completeness & Accuracy**

- All required sections present (Introduction, Methods, Results, Conclusions, etc.)
- Cross-check figures, tables, and references with text descriptions
- Ensure all data sources, formulas, and calculations are cited

✓ **Grammar & Language**

- Spellcheck and grammar check applied
 - Clear, concise, and professional language
 - Avoid ambiguity in technical descriptions
-

2. Site Feasibility & Placement Analysis

✓ **LFG monitoring methodology**

- Verification of LFG monitoring methodology
- Comparison of site conditions with feasibility criteria
- Documentation of site constraints (topography, accessibility, nearby structures)

✓ **Site Feasibility**

- Criteria for proposed biofilter locations
 - Validate buffer zones around biofilters, esp sites with solar arrays
-

3. Gas Composition & Emission Rate Assessment

✓ **Sampling & Analysis QC**

- Calibration logs for gas measurement instruments
- Cross-check sample collection timestamps & locations
- Duplicate or triplicate sampling verification

✓ **Data Integrity & Processing**

- Raw data compared against expected ranges
- Outlier validation (remove errors, justify anomalies)
- Correct gas and flux conversion factors applied

✓ **GHG emissions Rate Calculations**

- Verification of GHG emissions (MY CO₂e) modeling assumptions
 - Comparison with historical data & data from LandGEM tool
-

4. Regulatory Compliance & Standards

✓ **Emission Limits & Guidelines**

- Compare emission rates from vents with local/national guidelines
- Verify use of correct standard methods (e.g., EPA, ISO)

✓ **Permitting & Reporting**

- Confirm required permits are identified and addressed
 - Ensure reporting format meets state and federal regulatory guidelines
-

5. Stakeholder Engagement & Documentation

✓ **Meeting Records & Correspondence**

- Review stakeholder meeting minutes for accuracy
- Ensure key concerns and recommendations are documented

✓ **Community & Educational Campaign**

- Verify public engagement process
 - Ensure social/environmental impacts are adequately assessed
-

6. Final Review & Approval

✓ **Technical Review**

- Technical review by a second reviewer before submission
- Independent QAM check

✓ **Version Control & Sign-offs**

- Confirm correct versioning of reports
- Obtain sign-offs from project leads before submission

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To be filled out when there are project deliverables for sign-off.

Approvals on this form verify that all technical and editorial reviews have been completed and the deliverable meets the criteria for scientific defensibility, technical, and editorial accuracy, and presentation clarity.

QC Form Details		QC Review Information											
Item Number	File Name (Copy the name of this file in Reviewer)	Deliverable Description	Date Sent to Client	Deliverable Type (Dual) (Final)	Document Originator	Reviewer Type	Reviewer Name	Date Review was Performed	Brief Summary of Review Findings and Other Notes	Have all Findings been	Originator Signature (Use Employee)	Reviewer Signature (Use Employee)	QC Review Information (If Copy Log)
01				☐ ☐		Technical				☐ Yes			
						Editorial				☐ Yes			
02				☐ ☐		Technical				☐ Yes			
						Editorial				☐ Yes			
03				☐ ☐		Technical				☐ Yes			
						Editorial				☐ Yes			

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