LFG Wellfield Automated Remote Monitoring Plan

Chiquita Canyon Landfill
Castaic, California
SCAQMD Facility No. 119219

Waste Connections
29201 Henry Mayo Drive
Castaic, CA 91384

Submitted to:

South Coast Air Quality Management District
21865 Copley Drive
Diamond Bar, CA 91765
909-396-2000

SCS ENGINEERS

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15521 Midlothian Turnpike, Suite 305
Midlothian, VA 23113
804-378-7440

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1 INTRODUCTION

Chiquita Canyon, LLC (Chiquita) operates a municipal solid waste (MSW) landfill/solid waste disposal facility located in Castaic, California under South Coast Air Quality Management District (SCAQMD) Facility No. 119219. SCS Engineers (SCS) prepared this Landfill Gas Wellfield Automated Remote Monitoring Plan (Plan) on behalf of Chiquita in accordance with Condition No. 66 of the March 21, 2024 Modified Stipulated Order of Abatement (SOFA) (Case No. 6177-4) pertaining to the Chiquita Canyon Landfill (CCL, Facility, or Landfill).

Condition No. 66 requires:

> *Respondent shall install and operate a real-time, remote monitoring system which shall, at minimum, monitor well pressure and landfill gas temperature at different well depths (shallow, middle, deep). The remote monitoring system may include monitoring of fixed gases, oxygen, methane, and carbon dioxide, as well as wellfield tuning/optimization and well liquid level monitoring. By April 19, 2024, the Reaction Committee shall submit recommendations regarding installation of the remote monitoring system. By no later than June 21, 2024, contracts to install and operate the monitoring shall be finalized. The remote monitoring system shall be installed and in operation no later than October 22, 2024, on all wells operated in the Initial Reaction Area (defined as the boundary of Cells 1/2A, 2B/3, 4, and Module 2B/3/4 P2 as specified in Condition No. 9(a)).*

This Plan addresses the relevant considerations pertaining to automated remote measurement of pressure and temperature in landfill gas (LFG) wells and wellheads, as well as other operational parameters. The Plan also presents a discussion of instrumentation and equipment that may be utilized for measuring and recording various LFG wellfield operational parameters, including automated wellheads utilized within the LFG industry. The Plan further presents the Reaction Committee's recommendations regarding the installation and operation of the remote monitoring system.

OPERATIONAL PARAMETERS OF LANDFILL GAS EXTRACTION WELLS AND WELLHEADS

An evaluation and recommendation of any automated remote monitoring system for LFG wells and wellheads necessitates a comprehensive review of the operational parameters that are relevant to the monitoring of LFG collection systems. Furthermore, it is important to provide an inventory of the industry terminology associated with the operational parameters along with a detailed description of how the measurements of these parameters will be obtained in order to identify limitations and avoid any misunderstandings or differences in interpretations. The operational parameters for vertical LFG extraction wells and associated wellheads that are of interest for the purposes of data acquisition, either for wellfield balancing and tuning purposes or for regulatory compliance purposes, are outlined below:

- **Pressure:** The pressure within the wells and wellheads is typically recorded manually on a periodic basis by connecting field instrumentation to sampling ports at the wellhead. The pressure value can be positive or negative, and use of the term "vacuum" implies a negative pressure. The sampling ports are typically located on the upstream side of the wellhead control valve (often referred to as "static pressure"), which represent the pressure as measured in the well riser pipe, as well as the downstream side of the wellhead control valve (often referred to as "system pressure"), which represents the available vacuum in the LFG collection piping. Furthermore, the flow measurement device within the wellhead, such as a pitot tube or orifice plate, has sampling ports to record the differential pressure to calculate the flowrate of LFG through the wellhead. The LFG industry has historically measured a single static pressure value on the upstream side of the wellhead control valve at the top of the well riser pipe and has not employed multi-depth pressure sensors down into the well riser pipe.

- Temperature: The gas temperature within the wells and wellheads is typically recorded manually on a periodic basis by connecting field instrumentation to a sampling port at the wellhead. The sampling port used for gas temperature measurement is typically located on the upstream side of the wellhead control valve, which represents the temperature of the extracted gas as measured in the well riser pipe. The LFG industry has historically only measured the gas temperature value on the upstream side of the wellhead control valve at the top of the well riser pipe and has not employed multi-depth temperature sensors down into the well riser pipe. The temperature of liquids that may accumulate within the well can be recorded manually on a periodic basis by removing the wellhead and inserting a field instrument down into the well to measure liquid temperatures at various depths. The LFG industry has historically not employed multi-depth temperature sensors down into the well riser pipe because the sensor apparatus may potentially interfere with LFG and liquid extraction, and the temperature values were not deemed critically important to achieve proper operations at non-ETLF sites. The temperature of liquids being extracted from the well via a dedicated downhole dewatering pump is typically not measured within the discharge tubing or forcemain piping during routine operations.

- Gas Composition: The gas composition within the wells and wellheads is typically recorded manually on a periodic basis by connecting field instrumentation to a sampling port at the wellhead. The sampling port used for gas composition measurement is typically located on the upstream side of the wellhead control valve, which represents the gas composition of the extracted gas as measured in the well riser pipe. The chemical constituents that are measured by the field instrumentation traditionally used in LFG system monitoring are methane (CH_4), oxygen (O_2), and carbon dioxide (CO_2), with the remaining "balance" gas being correlated to the approximate nitrogen (N_2) content. Other chemical constituents that may be present in the LFG are typically measured only by obtaining a sample for laboratory analyses. The LFG industry has historically only measured the gas composition values on the upstream side of the wellhead control valve at the top of the well riser pipe and has not employed multi-depth gas composition sample tubing or individual sensors down into the well riser pipe.

- Flow: The flowrate of the gas extracted by the wells and wellheads is typically calculated using the differential pressure recorded manually on a periodic basis by connecting field instrumentation to sampling ports at the wellhead. As noted previously, the flow measurement device within the wellhead, such as a pitot tube or orifice plate, has sampling ports to record the differential pressure to calculate the flowrate of LFG through the wellhead. The LFG industry has historically not employed gas flowmeters on individual wellheads because there is no source of electric power (unless each well is outfitted with solar power and batteries) and the exorbitant cost does not justify providing electronic gas flowmeters rather than pitot tubes or orifice plates. The flowrate of liquids being extracted from the well via a dedicated downhole dewatering pump is typically not measured within the discharge tubing or forcemain piping for individual wells.

- Liquid Levels: The elevations and depths of liquids that may accumulate within the well can be recorded manually on a periodic basis by removing the wellhead and inserting a field instrument down into the well to measure the depth to top-of-liquid and calculate the corresponding elevation. The LFG industry has historically not employed liquid level sensors down into the well riser pipe because periodic manual measurement has been sufficient to achieve proper operations at non-ETLF sites and there are disadvantages with the various types of liquid level sensor equipment, as explained later in this Plan.

PURPOSE AND OBJECTIVES FOR THE REMOTE MONITORING OF OPERATIONAL PARAMETERS

The objectives related to the measurement and recording of the above-noted operational parameters associated with LFG collection systems, and the purposes for aggregating and analyzing the monitoring data, are noted below:

- Achieve appropriate balance and tuning of the wellfield to collect LFG at a sufficient extraction rate that optimizes the effectiveness and efficiency of the LFG collection system. This minimizes fugitive LFG emissions while simultaneously preventing air intrusion due to overdrawing the wells;

- Minimize off-site migration of subsurface gas;

- Minimize odors attributed to fugitive (uncollected) LFG emissions;

- Collect and control LFG in accordance with federal, state, and local air quality regulations, and air quality permit requirements;

- Protect the Landfill's bottom liner and final cover systems by controlling the accumulation of pressure due to the presence of LFG within the waste mass;

- Beneficial utilization of LFG for energy recovery when LFG serves as fuel for a landfill gas-to-energy facility, where applicable; and,

- Heat removal to contain and manage subsurface reactions at elevated temperature landfills, where applicable.

The periodic measurement of the operational parameters noted above (specifically, pressure, temperature, gas composition, flowrate, and liquid levels) at individual wells has been implemented by and evolved throughout the LFG industry over decades to equip operators of the LFG collection systems with information to enable the accomplishment of these multiple objectives. The accelerated advancement of technology associated with both the hardware and software elements of instrumentation, equipment, telemetry, and controls has facilitated the evolution of monitoring activities for certain operational parameters to be automatically measured on a continuous basis. This technique is referred to as "automated" or "remote," meaning it does not necessitate physically mobilizing a technician to the LFG well with hand-held field instrumentation, or as "real-time," meaning the measurements are being recorded instantaneously and these measurements are typically communicated to an electronic database or on-line platform.

The Reaction Committee has communicated the critical role the LFG extraction wells that are positioned within the Reaction Area serve to contain and manage the reaction and reduce the impacts to off-site communities. Chiquita and the Reaction Committee understand the purpose of an automated remote monitoring system for LFG wells positioned within the Reaction Area is to confirm proper operation and functionality of the wells in accomplishing their mission of dual-phase fluids removal (gas and liquid) and to assess the effectiveness of the wells in extracting heat and reducing off-site odors attributed to LFG fugitive emissions.

MONITORING INSTRUMENTATION AND EQUIPMENT

Pressure

The wells subject to being equipped with automated remote temperature monitoring instrumentation extract gas through the wellhead and extract liquids via a dedicated submersible pump connected to discharge tubing and forcemain piping. Condition No. 66 specifies that well pressure is to be measured at multiple well depths (shallow, middle, deep). Because system pressure (downstream of the wellhead control valve) and differential pressure (across the flow device) are measurements of the pressure as gas is flowing through the wellhead, are not obtained in the well itself, and cannot be made at multiple well depths, these parameters are not relevant to this evaluation.

The pressure measurement devices installed in wells at the Landfill will likely be exposed to both gaseous-phase and liquid-phase fluids that are present within the well riser pipe. Pressure measurement devices positioned above the liquid level will be measuring the applied downhole vacuum/gas pressures and, if devices were positioned below the liquid level, they will be monitoring the pore pressure, which in the well piping is equivalent to the hydrostatic head.

There is a vast universe of different types of pressure measurement devices (liquid column, elastic, electric, etc.) correlating to different scientific working principles, and different pressure measurement devices have historically been utilized in the LFG industry (digital and slack-tube manometers, electronic transducer, vibrating-wire piezometer, etc.). Previous wellhead pressure monitoring at other elevated temperature landfills (ETLFs) have utilized various types of electronic transducers.

Instrumentation suspended down into the well will need to co-exist with the submersible pump apparatus (pump, pneumatic supply line, liquid discharge tubing, pull-chain, etc.) and be resilient to interference during the insertion and removal of the pump and associated apparatus. Based on the Reaction Committee's collective experience, we are not aware of the LFG industry developing down-well, multi-depth pressure measurement devices that can co-exist with a submersible pump during pump servicing and maintenance activities (except where the device is affixed to the pump itself). While the multi-depth electronic pressure transducers may function suitably initially, they may become damaged or non-functional over time. Since multi-depth electronic pressure transducers may become damaged or non-functional over time, or prove to be infeasible because of compatibility with submersion in leachate or interference with a pump apparatus, a more viable approach is for automated remote measurement of the LFG flowing through the wellhead to be accomplished by a fixed pressure sensor positioned in the wellhead (rather than the well piping itself), which avoids interference with the pumps. This approach is consistent with the language in Condition No. 66 to provide a single pressure value at the wellhead.

Temperature

The language in Condition No. 66 specifies that LFG temperature is to be measured at multiple well depths (shallow, middle, deep). Therefore, temperature measurements of the gas flowing through the wellhead, and temperature measurements of liquids flowing through the tubing/forcemain, are not relevant to this evaluation.

Similar to pressure devices, the temperature measurement devices installed in wells at the Landfill will likely be exposed to both gaseous-phase and liquid-phase fluids that are present within the well riser pipe. Temperature measurement devices positioned above the liquid level will be measuring the gas temperature and devices positioned below the liquid level will be monitoring the liquid temperature.

Previous down-well temperature monitoring at other ETLF landfills have explored three types of equipment for temperature measurement instrumentation: thermocouples, thermistors, and fiber-optic cable.

Thermocouple: Standard thermocouples have historically not been suitable to withstand long-term deployment when subjected to leachate because the instrument life is limited to approximately one year. However, high temperature thermocouples encased in a stainless steel tubing jacket with powdered magnesium oxide in the interstitial space have yielded suitable performance for greater than one year. Because each thermocouple suspended at a particular depth interval requires a unique signal cable to be extended to the probe termination apparatus, there is a limit to the number of thermocouples that can be installed into a single well pipe. Accordingly, the Reaction Committee recommends suspending thermocouples at 40-foot intervals, up to a maximum of three thermocouples, which would yield a temperature value at the 40-foot, 80-foot, and 120-foot-depth intervals.

Thermistor: The materials within a thermistor change their resistance as their temperature changes. A thermistor temperature monitoring system applies a known current to a thermistor and the monitoring system calculates the temperature based on the resulting voltage from the thermistor. A thermistor string would be installed in each well riser pipe. Each thermistor string would be configured to monitor the temperature within the borehole every 25 feet. However, recent experience with the thermistor strings at another ETLF landfill indicated thermistors were unsuitable because of chemical incompatibility and/or because of the temperature design rating (approximately 260°F). For this reason, the Reaction Committee does not recommend the use of thermistors.

Fiber-Optic Cable: Looped fiber-optic temperature sensors are essentially a fiber-optic loop connected to a light source, photodetector, and controller that measure the scattering of the light and the traveling time of the light to measure the temperature and corresponding location along the loop. This system is vulnerable to whole system failure and offers little resiliency and reliability. Since the temperature monitoring device utilizes one string and one head-end, if either of these breaks the entire system is broken and no temperatures are read or recorded. For this reason, the Reaction Committee does not recommend the use of looped fiber-optic sensors.

An alternative to the above-described fiber-optic configuration is to equip each individual well with its own dedicated fiber-optic temperature monitoring system. The individual systems would include a down-hole fiber-optic loop with primary and secondary strings and a head-end monitoring unit. Each head-end monitoring unit would transmit its data to a control panel that could be recorded manually or via an Industrial Internet-of-Things (IIoT) transmitter to a cloud-based Remote Monitoring and Control (RMC) system to remotely view and interact with the data. However, the Reaction Committee does not recommend the use of individual fiber-optic sensors because of the complexity involved in the installation and operation of a large number of individual dedicated fiber-optic systems, which defeats the purpose of fiber-optic technology.

Instrumentation suspended down into the well will need to co-exist with the submersible pump apparatus (pump, pneumatic supply line, liquid discharge tubing, pull-chain, etc.) and be resilient to interference during the insertion and removal of the pump and associated apparatus. We are not aware of the LFG industry developing down-well, multi-depth temperature measurement devices that are likely to co-exist with the submersible pump during pump servicing and maintenance activities. While the multi-depth high-temperature encased thermocouples may function suitably initially, they may become damaged or non-functional over time. As noted in this Plan, the Reaction Committee recommends the use of thermocouples suspended into the well at multiple depths. However, if the multi-depth thermocouples become damaged or non-functional over time, or prove to be infeasible because of compatibility with submersion in leachate or interference with a pump apparatus, an appropriate substitute approach for consideration is for automated remote measurement of the LFG flowing through the wellhead to be accomplished by a single temperature sensor positioned in the wellhead (rather than the well piping itself), which will avoid interference with the pumps. This substitute approach would not provide multi-depth measurements, but could provide a single pressure value at the wellhead as a surrogate.

Gas Composition

There are two types of gas analyzers capable of measuring the major fixed gases or other select individual chemical compounds present in LFG that are commonly utilized in the LFG industry.

Gas Chromatograph/ Mass Spectrometer: Gas samples obtained from the upstream side of the wellhead control valve are suited to be filtered and conditioned before being transferred into a gas chromatography analyzer to determine gas composition and relative concentration amounts. The LFG produced under anaerobic conditions extracted from the wellfield contains fixed gases such as CH_4, CO_2, O_2, and N_2, which can be measured by a mass spectrometer (MS) after the vaporize compounds were previously separated by the gas chromatograph (GC) based on their chemical properties.

Both GC and MS tools are combined into one single device (GC-MS), which is equipped with a capillary column to where gases are pushed for further reaction with a carrier gas at constant flow rate (ex.: Helium). Laboratory analytical procedures typically utilize a syringe for transferring LFG field samples to the coupled GC-MS system. Field GC-MS units are not typically deployed to the wellheads, and the industry's more recent selection of instrumentation is various analyzer sensors, as demonstrated by the LoCI and APIS automated wellhead units; however, because any of this instrumentation requires the LFG sample to be removed out of the wellhead and through a sample conditioning apparatus and into a control panel containing the GC-MS unit (or analyzer sensors in the case of the LoCI and APIS equipment), it is not intrinsically safe and does not conform to electrical hazard classification requirements.

The Reaction Committee does not recommend the use of field GC-MS units at ETLF sites for the following reasons:

- The field GC-MS units are generally not rated for analyzing gas samples with a temperature exceeding 140 degrees Fahrenheit.
- The sample filters and conditioning apparatus will likely become frequently clogged because of the moisture content and solids content present in the reaction gas.
- Concerns regarding intrinsically safe rating.
- The field GC-MS gas analyzer components may malfunction since the internal gas molecule reactions within the analyzer, from heating the liquid sample to transporting vaporized compounds and ionization energy processes, are heavily dependent on temperature.

In-Line Sensors: A variety of electrochemical or infrared sensors can be deployed directly into the gas stream in the wellhead and connected via signal wire to a control panel for the measurement of fixed gas compounds. This eliminates the safety concern with electric hazard classification inherent with the sample filter apparatus and field GC-MS units contained in a box affixed to the wellhead. However, similar to field GC-MS units, the in-line sensors may not be viable for the high-temperature environment with the reaction gas extracted through the wellheads at ETLF sites.

Flow

For wellheads that employ an orifice plate as the flow measurement device, the differential pressure measurement can be measured by a pressure transducer and used to calculate an estimated flow. However, the wellheads installed at ETLF sites typically omit the orifice plate because it acts to restrict flow, which would be detrimental to the objective of maximizing heat removal through gas extraction at the wellhead. Accordingly, wellhead LFG flow measurement is typically excluded at wells positioned within the Reaction Area at ETLF sites.

Liquid Levels

There are two types of liquid level measurement devices commonly utilized in the LFG industry.

Submersible Level Transducer: The submersible level transducer requires a source of electric power and operates on the principle of differential pressure between the portion of the sensor submerged into the liquid present in the well and the portion maintained at atmospheric gage pressure in a control panel. An impediment to using this type of sensor at ETLF sites is that it is not rated for exposure to high temperatures.

Bubbler Level: The bubbler level requires a source of pneumatic supply and operates on the principle of measuring the pneumatic pressure required to release an air bubble from the bottom discharge opening of the housing tube submerged into the liquid present in the well. While it can operate in high temperature environments, one disadvantage is that it releases air into the LFG stream extracted from the well.

Wellhead Control Valve

The Reaction Committee is aware of three firms that offer a factory-fabricated automated wellhead with remote monitoring and remote control capabilities, as described below:

LoCI Methane Capture & Emission Reduction: According to the LoCI website, the LoCI Controller automated wellhead is a "wellhead-mounted device that captures data and enables measurement and control at each gas collection point." Along with the LoCI Liquid Level Measurement equipment, a listing of the components, features, and capabilities can be reviewed at https://locicontrols.com/loci-system.

SCS has extensive experience with the LoCI automated wellhead units deployed at numerous landfill sites, most commonly for the purpose of maximizing methane content for high-Btu energy recovery projects. Landfills that experiment with using these units often decide to discontinue and remove the equipment because the equipment provides no benefit to the efficiency and efficacy of the LFG collection system. SCS is not aware of the installation of LoCI automated wellheads or Liquid Level Measurement equipment at any ETLF sites. It is recognized that maximizing methane content is not relevant for the Reaction Area since it is not experiencing typical methanogenesis.

APIS Innovation: According to the APIS distributor website, the APIS smartWell automated wellhead device "places every component required for precision gas system tuning on each gas well in a solar-powered, wireless, self-contained, and practically maintenance-free package." A listing of the components, features, and capabilities can be reviewed at https://www.apisinnovation.com/products or https://www.ryanequipment.com/services-2. SCS is aware of one landfill in the northwestern US that has installed APIS units, but cannot comment on their performance. SCS is not aware of the installation of APIS automated wellhead equipment at any ETLF sites.

SCS-RMC: To-date, the SCS-RMC automated wellhead device has not been deployed on a broad scale (greater than 50 units) at multiple landfill sites. Unlike the LoCI and APIS units, the SCS-RMC automated wellhead utilizes in-line sensor technology and does not require pulling a gas sample into an analyzer sensor, thus, it avoids concerns with electrical hazard classification requirements and is intrinsically safe. Similar to the analyzer sensor equipment associated with the LoCI and APIS units, the in-line sensors may not be suitable for high-temperature environments, and they do not have experience on ETLF sites.

Telemetry System

The Reaction Committee has reviewed documentation, titled "Telemetry System Specifications", prepared by SCS and dated March 6, 2024, which outlines the proposed on-site telemetry hardware and software equipment. Based on discussions with the design engineers for the proposed telemetry system, and experience at other ETLF sites that have installed similar remote monitoring equipment, the Reaction Committee anticipates that this proposed system can be augmented to incorporate data obtained from the automated remote monitoring devices that are installed at the applicable LFG wells and wellheads.

RECOMMENDATIONS

Based on the information and considerations outlined in this Plan, and as more fully described above, the Reaction Committee offers the following recommendations for an automated remote monitoring system at the LFG wells and wellheads positioned within the Initial Reaction Area:

- Pressure: Install a single compound range (100 in-wc.) electronic pressure transmitter in the wellhead assembly upstream of the wellhead control valve to measure the static pressure (applied vacuum) in the well. The pressure transmitter shall be connected to an IIoT device on the wellhead.

- Temperature: Install three (3) high-temperature thermocouples encased in a stainless steel tubing jacket with powdered magnesium oxide in the interstitial space suspended into the well riser pipe at 40-foot depth intervals. These thermocouples shall be connected to an IIoT device on the wellhead.

- Gas Composition: The Reaction Committee does not recommend the deployment of either field GC-MS units or in-line sensors for wells within the Reaction Area at this time because we do not believe the instrumentation is appropriately rated to provide valid data for the high-temperature reaction gas being extracted at ETLF sites. Furthermore, we are concerned that the GC-MS units will be subject to frequent fouling because of solids and liquids in the gas stream and we are concerned that these units do not conform to electrical classification requirements.

- Flow: The Reaction Committee does not believe it is viable to provide remote monitoring capabilities for gas flowrate because the wellheads within the Reaction Area are typically not equipped with a flow measurement device since the device serves as a detrimental restriction to fluid extraction. We recommend installing a pneumatic cycle counter at each well equipped with a dedicated pneumatic pump. These cycle counters shall be connected to an IIoT device on the wellhead.

- Liquid Level: Install a bubbler liquid level measurement device at each well equipped with a pneumatic pump and pneumatic supply line. These bubbler levels shall be connected to an IIoT device on the wellhead. We recommend that any electric pumps in wells be equipped with a submersible level transducer as a pilot test to assess the function and viability of this instrumentation. If these transducers prove to be problematic regarding compatibility with leachate and/or high-temperatures, we recommend that wells with electric pumps be equipped with electric-powered bubbler level equipment.

- Wellhead Control Valve: The Reaction Committee does not recommend automated wellheads be introduced for ETLF wells at the Landfill based on the rationale presented under the Gas Composition section above. Also, considering the collective experience that automated wellheads have been decommissioned from typical MSW sites due to detrimental performance as frequently as they have been commissioned, we do not believe that they will prove beneficial at ETLF sites. While the algorithm for high-BTU landfill gas-to-energy sites is fairly straight-forward, the criteria governing the adjustment of the control valve at an ETLF site would likely result in undesirable consequences with respect to throttling the valve open or closed.

- **Telemetry:** Install a single battery or solar-powered cellular remote IIoT device at each wellhead being equipped with remote monitoring instrumentation to compile the pressure and temperature measurement values from the instrumentation. This IIoT device shall power the sensors and communicate data to a cloud-based Supervisory Control and Data Acquisition (SCADA) system in accordance with the telemetry system specifications outlined in the documentation previously referenced.

Please contact the Reaction Committee if there are any questions regarding this evaluation and the recommendations, or if further information related to automated remoted monitoring system instrumentation and equipment is required.