Landfill Gas Generation Study
Lockwood Ash Disposal Site

Lockwood Hills LLC
Dresden, New York

June 2021

Prepared by

EnSol
ENGINEERING +
ENVIRONMENTAL

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EnSol, Inc.
661 Main Street
Niagara Falls, New York 14301

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1. Introduction

Lockwood Hills LLC (Lockwood Hills) manages the Lockwood Ash Disposal Site (Lockwood or the Facility), an ash monofill located in the Town of Torrey, Yates County, New York on Swarthout Road. The Facility is bounded by Swarthout Road to the east, and by Feagle Road to the south. Lockwood Hills maintains a 6 NYCRR Part 360 Series Solid Waste Management Facility permit (Permit No. 8-5736-00005/00003-0) for the Facility. The permit issued by the New York State Department of Environmental Conservation (NYSDEC) allows Lockwood to accept fly ash, bottom ash, pulverizer mill rejects and wastewater treatment plant sludge from several specifically named power generation facilities including the Greenidge Power Generating Station.

In a Notice of Incomplete Application dated March 3, 2020 the New York State Department of Environmental Conservation (NYSDEC) requested that a gas generation study be performed at Lockwood to determine the gas generation rate from the waste mass and the composition of this landfill gas. Their objective for this study is to determine the need for landfill gas management in the closure design at Lockwood. In response to this request, Lockwood developed a soil gas sampling protocol to determine the composition of gas generated from the landfill and the associated gas generation rate (Attachment 1). This report presents the results of the soil gas sampling, as well as a literature review of gas generation in landfills with similar waste composition.

2. Literature Review

A literature review regarding the potential for gas generation in a coal ash monofill was conducted to review other documented cases of landfill gas generation in landfills with a similar waste composition to Lockwood. No peer-reviewed articles were found documenting this specific phenomenon. A document sponsored by the U.S. Department of Energy (Elcock & Ranek, 2006) states that multiple cases were identified where variances were granted because landfill gas management was not appropriate or necessary for a disposal unit that manages coal combustion wastes. Similarly, the U.S. Environmental Protection Agency's (U.S. EPA's) Landfill Gas Emissions Model (LandGEM) Version 3.02 User's Guide (Alexander et al., 2005) states that "non-biodegradable waste (i.e. inert material), such as ash from waste combustion may be subtracted from the Waste Design Capacity, depending on documentation and approval from a regulatory authority." indicating that the U.S. EPA does not anticipate ash to be a meaningful source of landfill gas. Reference citations may be found in Appendix 4.

An article provided by the NYSDEC (Musselman et al., 2000) indicates the potential for hydrogen gas (H_2), methane (CH_4), hydrogen sulfide (H_2S), and non-methanogenic organic compounds (NMOCs) from ash monofills. The subject landfill in this paper is a municipal waste combustor ash monofill, rather than a coal ash monofill, and is therefore not directly applicable to Lockwood. Furthermore, the authors note that results from a comprehensive ash sampling and analysis program showed that there was incomplete combustion of the waste with moderate to high percent Loss on Ignition averaging 6.4%. This indicates that the landfill had a considerable amount of biodegradable content. Ash samples from Lockwood also had a relatively high Loss on Ignition, but unburned coal is not biodegradable. However, some insights from this paper indicate that minor gas generation potential may exist at the LADS.

Musselman et al. describe how oxidation reduction reactions of elemental metals (e.g., aluminum or iron) may generate hydrogen gas. Their discussion focuses largely on aluminum, which reacts with water to form H_2 and, depending on conditions, aluminum oxide (Al_2O_3), boehmite (AlOOH), or aluminum hydroxide ($Al(OH)_3$). An oxide layer protects elemental aluminum from corrosive reactions with water, but this layer can be disrupted by factors such as pH lower than 4 or higher than 9 and the presence of chloride ions. A pH below 4 or greater than 9 has never been observed in Lockwood leachate. Chloride has been detected in Lockwood leachate samples throughout the history of sampling for this parameter (2003 – 2020), so there is potential for chloride ions to disrupt the oxide layer, allowing for corrosive H_2 forming reactions between Al and H_2O to take place.

Musselman et al. also list chromium, copper, iron, and zinc as other elemental metals that, through oxidation reduction reactions can produce H_2 gas. Iron and copper have been shown to have H_2 generation potential at pH 13.5, but not between pH 9.3 and 11.4 (Magel as cited in Arm and Lindeberg, 2006). The reported pH value of 13.5 is higher than any reported in the landfill leachate, so copper and iron are unlikely to be part of a reaction that will produce H_2 gas at Lockwood. Another study showed that of mixtures with aluminum, lead, magnesium, and zinc placed in NaOH solution, only the ash-aluminum mixture generated H_2 gas (Péra et al. as cited in Arm and Lindeberg, 2006).

Not only are current or historic conditions within the landfill not conducive for H_2 gas production, elemental metals available within the waste to support such reactions are low, as suggested by the low levels of these metals in landfill leachate. Chromium has not been detected in landfill leachate since September of 2011 and historic fly ash samples indicate low concentrations of this metal. In 2005, chromium was found in fly ash samples at 0.026 mg/L, while in 2007 it was below the detection limit of 0.01 mg/L. Copper and zinc are both found periodically in leachate samples but are typically at concentrations below 20 µg/L. Iron is found in much larger concentrations than any of these other metals ranging from less than 0.01 mg/L to over 100 mg/L. Reduced concentrations of aluminum in recent leachate samples (post-2011) at most leachate sampling locations relative to historic conditions, indicate a reduced potential for H_2 generation from oxidation reduction reactions involving aluminum. It should be noted that the study by Arm and Lindeberg states that it is the content of elemental aluminum, not total aluminum that influences the amount of H_2 generation. Musselman et al. (2000) also state that it is the oxidation of elemental aluminum, zinc, chromium, iron, copper, and other elemental metals under the right environmental conditions that contribute to H_2 generation.

Musselman et al. also noted a small amount of CH_4, generation, likely from a low-level of methanogenic bacterial activity, production of H_2S, which was likely the result of microbial activity in the landmass, and low concentrations of NMOCs. Due to the presence of organic matter disposed of in the landfill following the disposal of dredged pond sediment and associated vegetation there is a limited potential for a small amount of CH_4, H_2S, and NMOCs to be generated where this material was landfilled as organic matter present decomposes. Methane, H_2S, and NMOC production is not anticipated in other areas of the landfill because these compounds are produced through the bacterial degradation of organic matter. Further, it is unlikely that bacterial populations, including sulfate-reducing bacteria, will be present in CCR waste outside of the area where organic matter was landfilled because bacteria need organic matter to sustain their metabolism and growth (Muyzer & Stams, 2008).

Carbon monoxide was also included in the list of parameters for the Lockwood gas generation study, however, it is unlikely that CO will be a substantial component of any gas detected. This gas is typically found at levels between 0 and 3% by volume in municipal solid waste landfill gas, with normal levels being around 0.001% by volume (Gendebien et al. as cited in Fischer et al. 1999), with higher values indicating possible combustion in the waste mass. Similarly, the U.S. EPA's Fifth Edition of Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources (2008) states that CO is not a typical component of landfill gas but is associated with underground combustion of the waste mass. No fires have ever been reported at Lockwood, nor are any expected to occur based on the type of waste landfilled, so the potential for significant quantities of CO in the soil gas samples is low.

3. Soil Gas Sampling Results

Soil gas sampling was conducted by EnSol, Inc. on June 15, 2021, in general accordance with the NYSDEC reviewed Gas Generation Soil Gas Sampling Protocol. This protocol was revised slightly during June of 2021 based on the availability of rental equipment and a change to the method for measuring velocity. This revised protocol was sent to the NYSDEC on June 10, 2021. No additional comments from the NYSDEC were received.

On the date of sampling, there was light rain in the early morning, which subsided around 9:15 am. After this time, the weather conditions were overcast with slight wind and temperatures ranging from approximately 64 to 82 °F.

The soil gas sampling results were recorded on a field data form and have been included with this report as Attachment 2. Representative photographs from the sampling event are included in Attachment 3. Samples were taken at seven points throughout the site, including an initial upwind point (UW1), initial downwind point (DW1), four landfill waste points (LW1 through LW4), and a final downwind point (DW2). Upwind and downwind ambient air sampling locations were chosen based on the wind direction observed at the time of sampling. The actual locations of all seven sampling points are identified in Figure 1.

Three measurements were taken at each of the landfill waste points; one ambient air measurement, one measurement directly after sampling tools were lowered into the borehole and clay was used to seal the opening, and one following purging two borehole volumes of air (4.69 liters) from the borehole. Point LW1 was taken in the Original Ash Disposal Site (OADS), LW2 was taken in the overfill liner area, LW3 was taken in Stage II, and LW4 was taken in Stage I within the 2019 confined disposal area where ash contaminated sediment associated with upgrades to the Treatment Pond were disposed.

Cover and waste composition are described on the field data form and generally reflect what was expected at each location. Sample point LW1 had approximately two feet of final cover soils underlain by grey fly ash. Sample point LW2 had approximately 2.25 feet of intermediate cover soils underlain by grey fly ash. At about five feet deep the ash in LW2 became wet for an inch or so, before becoming drier again at the bottom of the borehole. Sample point LW3 had approximately 1.1 feet of intermediate cover soils underlain by black fly ash. Sample point LW4 had approximately two feet of cover soils underlain by ash contaminated soils with much higher clay content than waste observed at any other sample points. This is presumed to be from deposition of the clay liner removed from the Treatment Pond prior to installation of the new geosynthetic membrane liner system.

Cover soils were dry at all locations, despite rain earlier in the day. The waste at sample point LW4 seemed to retain some moisture, likely due to its higher clay content, but was not saturated. Recognizable organic matter (e.g., roots) were only visible in the first few inches of cover soils, associated with grasses, clovers, and other species growing atop the landfill.

The results from the testing are presented in Table 1. There are a few observations that should be mentioned. First, all gases were observed at levels well below their lower explosive limit. Second, static and differential pressure measurements were recorded but are not accurate because the required pitot tube fitting was not provided with the rental equipment. The static and differential pressure readings are, therefore, excluded from further discussion.

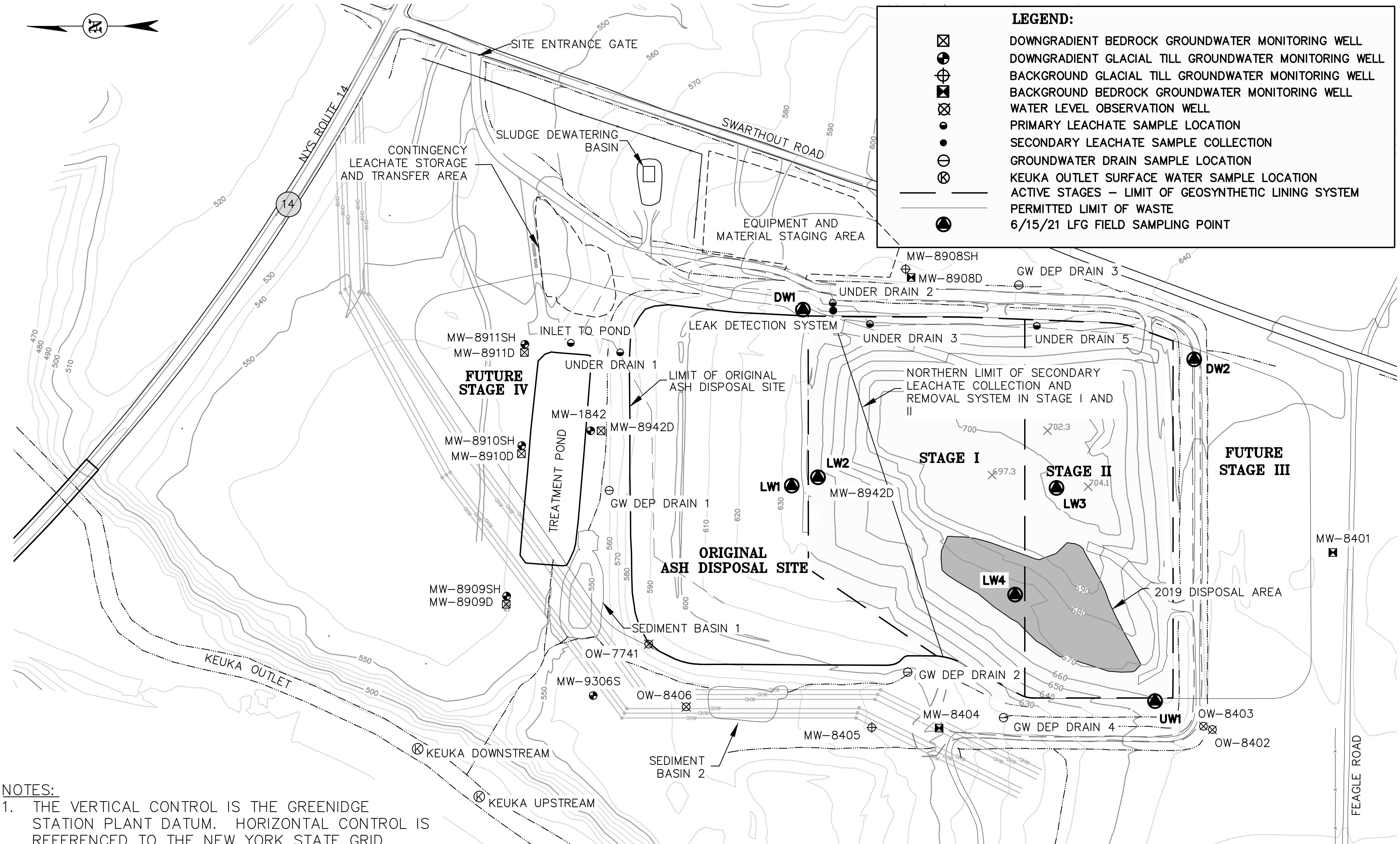
TABLE 1: LANDFILL GAS COMPOSITION AND VELOCITY RESULTS

	Parameter	CH_4	CO_2	O_2	Balance	CO	H_2S	H_2	Temp	Velocity
	Units	**%**	**%**	**%**	**%**	**ppm**	**ppm**	**%**	**°F**	**mph/fpm****
Location										
UW1		0.2	0.1	21.2	78.6	1	0	< 0.01	64.3	9
DW1		0.2	0.2	21.1	78.7	1	0	< 0.01	65.6	9
DW2		0.2	0	21.1	78.7	1	0	< 0.01	82	7
LW1	Ambient	0.2	0.1	21.2	78.5	1	0	< 0.01	67.7	7
	Initial	0.2	1.4	19.5	78.5	11	0	< 0.001	66.1*	-
	After Purge	0.1	0.7	20.5	78.6	1	0	< 0.01	66.3*	1.2 (0 - 2.4)
LW2	Ambient	0.2	0.1	21.4	78.4	1	0	< 0.001	66.8	12
	Initial	0.2	0.9	20.9	78.1	7	0	< 0.01	66.8*	-
	After Purge	0.1	0.8	20.8	78.3	2	0	< 0.001	59.6	2.7 (0 - 5.4)
LW3	Ambient	0.2	0.1	21.4	78.4	0	0	< 0.01	67.3	12
	Initial	0.2	0.4	18	81.4	13	0	< 0.01	59.7	-
	After Purge	0.2	0.5	18.6	80.8	1	0	< 0.001	57.2	2.95 (0 - 5.9)
LW4	Ambient	0.2	0.1	21.2	78.6	1	0	< 0.001	79.2	8
	Initial	0.2	1	20.2	78.6	4	0	< 0.01	78	-
	After Purge	0.1	0.8	20.2	78.9	2	0	< 0.001	80.9	5.2
Avg. Ambient		0.2	0.1	21.2	78.6	0.9	0		70.4	9.1
Avg. Initial LW		0.2	0.9	19.7	79.2	8.8	0		67.7	-
Avg. After Purge LW		0.1	0.7	20.0	79.2	1.5	0		66.0	3.0

*The temperature probe was positioned near the top of the borehole, likely biasing the temperature toward ambient air conditions. For all other LW readings, the temperature probe was positioned at the bottom of the borehole.
**Ambient readings are in miles per hour (mph) and After Purge LW readings are in feet per minute (fpm).

Lastly, velocity readings at all landfill waste points would begin at zero and increase slowly to a peak value. In LW1, LW2, and LW3, the velocity readings were erratic, fluctuating over the entire duration of measurement. Some, but not all fluctuations were noted in response to gusts of wind, although this was corrected by holding a plastic bag over the top of the PVC pipe to preclude air from entering the top of the pipe. For this reason, an average between zero and the peak value is most representative for gas velocity as presented in Table 1 for these three landfill waste sample points. The fluctuation seen at other landfill waste points was not observed at LW4, therefore, the peak reading at LW4 was considered most representative.

The velocity of gas flow measured at the landfill waste sample locations ranged from 1.2 to 5.2 feet per minute (fpm) with a peak velocity measurement range of 2.4 to 5.9 fpm. The cross-sectional area of the pipe was approximately 0.02 square feet. Thus, the volumetric flow rates ranged from 0.03 to 0.11 cubic feet per minute (cfm) with a maximum peak value of 0.13 cfm.



NOTES:

1. THE VERTICAL CONTROL IS THE GREENIDGE STATION PLANT DATUM. HORIZONTAL CONTROL IS REFERENCED TO THE NEW YORK STATE GRID.
2. THE TOPOGRAPHIC INFORMATION WAS PROVIDED BY KUCERA INTERNATIONAL, INC. BASED ON A FLYOVER PERFORMED ON FEBRUARY 4, 2010. PLANIMETRIC INFORMATION FROM "EXISTING SITE CONDITIONS" BY FAGAN ENGINEERS (FILE NUMBER 2K003-1) DATED APRIL 2000.
3. THE TOPOGRAPHIC INFORMATION ON THE ACTIVE STAGES OF THE LANDFILL WERE UPDATED WITH GROUND SURVEY FROM RICHARD WILLSON, PLS OBTAINED IN APRIL 2011 AND SUPPLEMENTED WITH SURVEY FROM WILLSON ASSOCIATES IN AUGUST 2019.

SITE PLAN WITH LFG SAMPLE POINTS

GAS GENERATION STUDY

LOCKWOOD HILLS LLC
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FIGURE 1

JUNE 2021 | PN: 21-0002-05b

4. Discussion

The most significant finding of the study is that the low concentrations of CH_4 measured in all sample locations, including ambient and LW sample points, are within the instruments margin of error. Calibration information for the GEM5000 Plus indicates a margin of error of +/- 0.3% for CH_4. Additionally, ambient air concentrations for CO and CO_2 at 1 ppm and 0.1% are also within the instrument's margin of error of +/- 1 ppm for CO and +/- 0.5% for CO_2. Calibration information for the HY-ALERTA™ did not provide margin of error information, however, the manual states that the meter's range is 0.0015 to 100%, therefore a reading of < 0.001% is below the operating range of the meter. The calibration information for both meters is included at the end of Attachment 2.

Given the above stated margin of errors, ambient air measurements at all locations were typical (http://tornado.sfsu.edu/geosciences/classes/m201/Atmosphere/AtmosphericComposition.html, accessed on June 17, 2021).

The gas composition observed in the LW sampling points is characterized by slightly depressed O_2 levels and slightly elevated CO_2 and CO levels, above the instrument's margin of error, as compared to the ambient air. The composition of gas at the landfill waste points was similar before and after purging. Purging did not appear to have a significant effect on the gas composition. The exception to this is the measurements of CO, which were elevated in initial borehole samples relative to both ambient and post-purge measurements.

The composition of gas in a typical landfill changes as the waste progresses through four phases of decomposition (Agency for Toxic Substances and Disease Registry, 2008, adapted from U.S. Environmental Protection Agency (USEPA), 1991). A graph depicting typical landfill gas concentrations in each phase is included in Figure 2. The composition of gas at all landfill waste sample points indicate a gas composition typically seen at the very beginning of Phase 1.

Phase 1 typically occurs in a span of days to months, yet waste at Lockwood has been in place for a minimum of two years to as much as four decades. If there was any appreciable degradation occurring, Phase 1 decomposition would have been completed by this time. Further, if a substantial amount of aerobic decomposition were occurring in the landfill, the oxygen in the landfill gas should have been depleted much more significantly over the past several years and concentrations of CO_2 and H_2 would have increased sharply. This was not the case as shown by the gas composition at all LW sampling points..

Another indicator of the lack of decomposition is the measured temperatures. The temperatures observed at points LW1, LW2, and LW3 are all below the range of temperatures typically seen in landfills due to biological activity (77 – 113 °F). The temperatures recorded at sample point LW4 were at the lower end of this range, but gas composition was not reflective of ongoing decomposition.

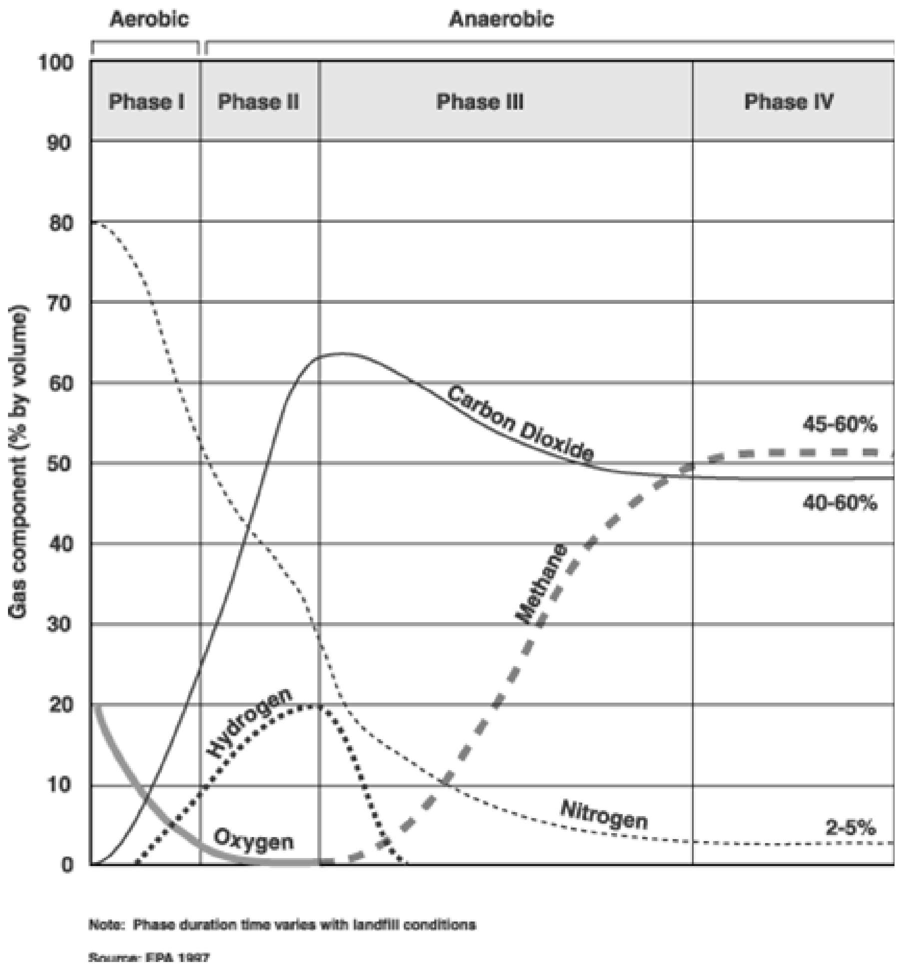


FIGURE 2: PRODUCTION PHASES OF TYPICAL LANDFILL GAS

Overall, the observed gas composition and concentrations in the LW sampling point were not reflective of landfill gas associated with any of the subsequent stages of decomposition. Thus, the argument that there is negligible decomposition occurring in the Lockwood landfill is supported by this study.

The equilibrium flow rates were all below 0.2 cfm, orders of magnitude lower than those reported in the study by Musselman et al. referenced by the NYSDEC. Flow rates in the Musselman et al. study ranged from 20 to 60 cfm. Musselman et al. also reported that flow rates between 30 and 60 cfm are typical of what might be expected at steady state conditions in an active municipal solid waste landfill. Additionally, Shaw Environmental Inc. (2005) reported flow rates of 13 standard cubic feet per minute (scfm) during a test on a passive vent system installed in Section E of a 150-acre landfill at Fort Ord in California. Fort Ord landfill was used to dispose of residential and limited amounts of commercial waste (U.S. EPA, 2021). These measurements were taken in 2003 nearly a decade after the landfill closed in 1994. The passive nature of a vent system closely approximates the conditions under which gas flow was measured at Lockwood. If the maximum flow rate seen at Lockwood were converted to scfm using the barometric pressure at the time of sampling taken from a nearby weather station and the temperature recorded directly after purging the maximum flow rate observed at Lockwood is 0.13 scfm, two orders of magnitude lower than that reported at the Fort Ord landfill. The volumetric flow rates measured at the landfill waste sampling points do not suggest that a gas management system will be necessary at the Lockwood.

5. Summary

As requested by the NYSDEC, this gas generation study was conducted to define the gas generation rate and gas composition of landfill gas at Lockwood and to determine if there is need for a landfill gas management system at Lockwood. Based on the concentrations and composition of gas sampled from the landfill waste sample points, there appears to be no evidence of significant decomposition occurring within the waste mass of the landfill. Volumetric flow rates measured onsite are orders of magnitude lower than those reported for a municipal waste combustor ash monofill (Musselman et al., 2000) and a passive venting system in a closed residential and commercial waste landfill (Shaw Environmental Inc., 2005). Based on the evidence gathered from this study, a landfill gas management system is not considered necessary to maintain the integrity of the final cover system at Lockwood.

Attachment 1

Soil Gas Sampling Protocol

EnSol, Inc.
661 Main St.
Niagara Falls, NY 14301
716.285.3920

ensolinc.com

Memorandum

Date: June 10, 2021

To: File

From: EnSol, Inc.

RE: Lockwood Ash Disposal Site
Soil Gas Sampling Protocol, Rev. 2

The following is a protocol for the soil gas sampling event set to take place at the Lockwood Ash Disposal Site (the Site) during the spring of 2021.

SAMPLE LOCATIONS (see Attachment 1):

1 = Pre-Disturbance Downwind Background Ambient Air, Sample DW1

2 = Upwind Background Ambient Air, Sample UW1

3 = Original Ash Disposal Site, Point LW1

4 = Stage I Overfill, Point LW2

5 = Stage I; within 2019 disposal area, Point LW3

6 = Stage II; outside the 2019 disposal area, Point LW4

7 = Post-Disturbance Downwind Background Ambient Air, Sample DW2

ANALYTES: Field Measurements Only – CH_4, CO_2, O_2, CO, H_2S, H_2, balance gas, temperature, static pressure, differential pressure, and flow

<u>STANDARD OPERATING PROCEDURE</u>:

1) General Procedure
    a. Three weeks prior to event:
        i. Purchase AMS Telescoping Regular Auger Kit (2 ¼” diameter), or equivalent, from EnviroSupply & Service
        ii. Purchase molding clay from Michaels (2 1-lb blocks)
        iii. Purchase plastic sheeting from Home Depot (10ft x 25 ft)
        iv. Purchase 2” ID Schedule 40 PVC Pipe from Home Depot
    b. One week prior to event:
        i. Rent 1 Landtec GEM5000 Plus Landfill Gas Monitor, or equivalent, from Pine Environmental
        ii. Rent 1 Dwyer Model 471B Digital Thermo Anemometer from Field Environmental Instruments
        iii. Rent 1 HY-ALERTA 500 Handheld Hydrogen Leak Detector from Field Environmental Instruments
        iv. Check forecast to ensure sample date will not fall within 48 hours of a rainfall event of 0.5 inches or greater
        v. Contact Lockwood (Chris Gill) and arrange for access to the Site
    c. One day prior to event:
        i. Collect necessary equipment (See equipment list at end of this SOP)
        ii. Double check forecast for the following day
        iii. Confirm site access arrangements with Lockwood (Chris Gill)
    d. Day of sampling event
        i. Load required equipment into vehicle and travel to Site
        ii. Roughly determine wind direction using a wetted finger or a lighter flame to identify pre-disturbance downwind and upwind background ambient air sample locations
        iii. Walk to the pre-disturbance downwind sample location and record the location with a handheld global positioning system (GPS), then take an ambient air reading (See Step 2)

iv. Confirm wind direction, then walk to the upwind sample location and record the location with GPS, then take an ambient air reading (See Step 2)
v. Walk to the first LW location and record the location with GPS
vi. Advance borehole and take measurements (See Step 3)
vii. Collect a representative sample of excavated materials, then return excavated materials to the borehole, taking care to restore the intermediate cover thickness and grass plug
viii. Repeat Steps 1(d)(v) through 1(d)(vii) for each LW sampling location
ix. Again, confirm wind direction, then walk to the post-disturbance downwind sample location and record the location with GPS, then take the final ambient air reading (See Step 2)
x. Pack up and return to office

e. Day after sampling event
   i. Upload field data and photographs and scan in Field Observation Forms
   ii. Email Lockwood Hills LLC staff with sample point locations so intermediate cover can be reapplied to those areas, if necessary
   iii. Return rental equipment

2) Ambient Air Sample Collection
   a. Start the GEM5000 and allow the machine to self-test (approx. 10 seconds)
   b. Go through Preliminary Checklist (See Attachment 2)
      i. During Step 2 of the checklist choose the GEM5000 setting for landfill gas analysis
   c. Select ID
   d. Position the inlet probe of the GEM5000 one to two inches above the ground
   e. Allow analyzer to purge with fresh air (approx. 30 seconds)
   f. Use the temperature probe to obtain a temperature reading one to two inches from the ground. Record this value on the data sheet and enter it into the GEM when prompted.

g. Press fan button to start sampling ambient air. Allow readings one to two minutes to stabilize. Record measurements for the ambient air sampling point in the GEM5000 and on a Field Observation Form.
    i. When prompted for a temperature measurement use the Dwyer probe to obtain a temperature reading at the same height as the inlet probe on the GEM5000. Record the temperature on a field data form and enter it into the GEM5000 as prompted.

h. Holding the probe tip sensor of the HY ALERTA probe at the same height as the GEM5000 inlet probe, obtain a measurement of H_2 gas and record on a field data form.

3) LW Sample Collection
    a. Have the other team member perform an ambient air measurement as near to the sample location as possible (see Step 2)
    b. Have one team member advance a borehole to a depth of 5.5 feet using a hand auger, placing excavated materials on plastic sheeting, with the cores in the order they were removed from the borehole
        i. If materials encountered are resistant to the hand auger the field sampling team may choose to create a borehole and sample a different location within the same landfill cell
        ii. Avoid generating dusty conditions by gently placing excavated materials onto the plastic sheet
    c. Connect clear sample tube to white port and the sample point
    d. Lower the white tube from the GEM5000 and the probe from the HY ALERTA to a depth of approximately 5 feet. Once the tubing and probe are at the required depth the opening of the borehole shall be sealed using molding clay. Insert the Dwyer probe vertically through the top of clay so temperature can be entered when prompted by the GEM5000. Use a sharpie to punch the hole and reform clay around the probe to prevent possible damage to the probe tip.

e. Purge two sample volumes at a rate of 550 cc/min for approximately 17 minutes. This should equate to approximately 4.69 liters. Record calculated purge volume, rate, and duration of each purge on a Field Observation Form
f. While purging is ongoing, have one team member characterize the core removed during excavation of the borehole (See Step 4)
g. Once purging is complete follow the steps outlined in the GEM5000 Operating Manual (Attachment 3) and the on-screen directions to collect the required measurements. Record measurements on data sheets.
    i. When directions call for disconnecting tubes from the sample point remove them from the ports on the GEM5000
    ii. In addition to saving measurements in the GEM5000 the readings should also be noted on a Field Observation Form in the case data in the GEM5000 becomes corrupted
h. Once purging is complete and readings appear stable, use the HY ALERTA probe to obtain a measurement of H_2. Record this value on the data sheet.
i. Remove clay, tubing from the GEM, Dwyer probe, and the HY ALERTA probe from the borehole.
j. To measure flow, fit the PVC pipe into the borehole and insert the Dwyer probe into the hole drilled on the PVC pipe with the dot on the probe facing into the flow (i.e., dot facing bottom of borehole). Seal the hole around the probe with clay. Turn the meter on and wait for readings to stabilize. Record the velocity of gas flow in feet per minute. Record this value on the data sheet. This value can be converted to a volumetric flow rate based on the cross-sectional area of the PVC pipe.

4) Characterization of Excavated Materials
    a. While one sampling team member watches the GEM5000 to ensure proper functioning during the purging period, the other team member should characterize the materials excavated from the borehole

    i. Expected materials include intermediate cover as defined in the Site's O&M Manual, fly ash, bottom ash, pulverizer mill rejects, sludge/ash mixtures, and materials associated with dredging of the Treatment Pond.

b. Record observations on a Field Observation Form and collect a representative sample in a glass jar. Label the jar with the date and sample location.
c. Once characterization of the materials is complete the plastic sheeting should be folded over to prevent wind action on the materials from generating dust until the materials are returned to the borehole

EQUIPMENT LIST:

1 Landtec GEM5000 Plus Landfill Gas Analyzer (Rented from Pine Environmental)

1 Dwyer Model 471B Digital Thermo Anemometer

1 HY-ALERTA 500 Handheld Hydrogen Leak Detector

1 AMS Telescoping Regular Auger Kit (2 ¼" diameter)

1 2" ID Schedule 40 PVC Pipe with a 25/64" hole drilled two feet from the bottom of pipe

1 GPS unit

1 Molding clay

1 Plastic sheet (10 ft x 10 ft)

1 Utility knife to cut plastic sheeting

1 Water bottle

1 Lighter

1 Field observations form

1 clip board and ballpoint pen

1 permanent marker (fine point)

1 timer device (e.g., cell phone)

1 Electronic copy of Landtec GEM5000 Landfill Gas Analyzer Operating Manual

1 Measuring tape

1 Shovel

1 Garbage bag

2 Sets of personal protective equipment (see below)

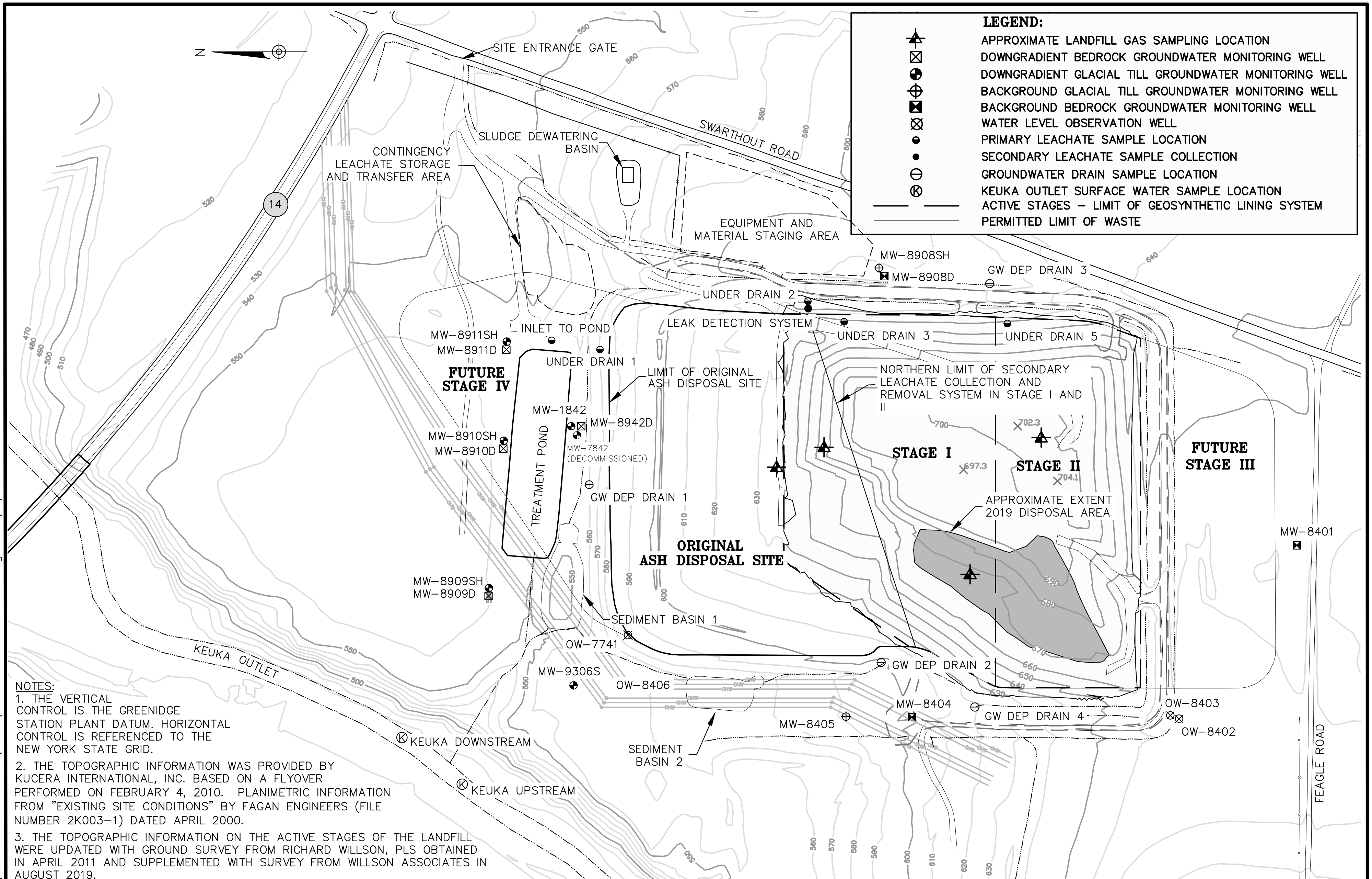
PERSONAL PROTECTIVE EQUIPMENT AND ACTIONS FOR WORK WITH FLY ASH:

- Face and Eyes: Goggles or safety glasses
- Clothing: Long sleeves, long pants; waterproof/resistant materials recommended
- Hands: Work gloves or butyl rubber gloves
- Feet: Shoes or work boots; boot covers recommended
- Wash exposed skin thoroughly after exposure
- Launder dusty or wet clothing after exposure to fly ash

- Dust generation and potential risk of inhaling fly ash will be minimized using operational controls including careful movement and placement of excavated materials and covering the materials with plastic sheeting following material characterization

ATTACHMENT 1

Schematic Site Plan



NOTES:
1. THE VERTICAL CONTROL IS THE GREENIDGE STATION PLANT DATUM. HORIZONTAL CONTROL IS REFERENCED TO THE NEW YORK STATE GRID.
2. THE TOPOGRAPHIC INFORMATION WAS PROVIDED BY KUCERA INTERNATIONAL, INC. BASED ON A FLYOVER PERFORMED ON FEBRUARY 4, 2010. PLANIMETRIC INFORMATION FROM "EXISTING SITE CONDITIONS" BY FAGAN ENGINEERS (FILE NUMBER 2K003-1) DATED APRIL 2000.
3. THE TOPOGRAPHIC INFORMATION ON THE ACTIVE STAGES OF THE LANDFILL WERE UPDATED WITH GROUND SURVEY FROM RICHARD WILLSON, PLS OBTAINED IN APRIL 2011 AND SUPPLEMENTED WITH SURVEY FROM WILLSON ASSOCIATES IN AUGUST 2019.

Q:\Lockwood Hills LLC\ACAD\SCHEMATIC SITE PLAN.dwg 10/6/2020 12:06 PM

DAIGLER ENGINEERING, P.C.
CIVIL & GEO-ENVIRONMENTAL ENGINEERING
2620 GRAND ISLAND BLVD. GRAND ISLAND, NEW YORK 14072
(716) 773-6872 (716) 773-6873 FAX

LOCKWOOD HILLS LLC		SCHEMATIC SITE PLAN LOCKWOOD ASH DISPOSAL SITE			FIGURE 1-1
SCALE: 1"=350'	REVISION # 0				
October 2020		TOWN OF TORREY	YATES COUNTY	NEW YORK	

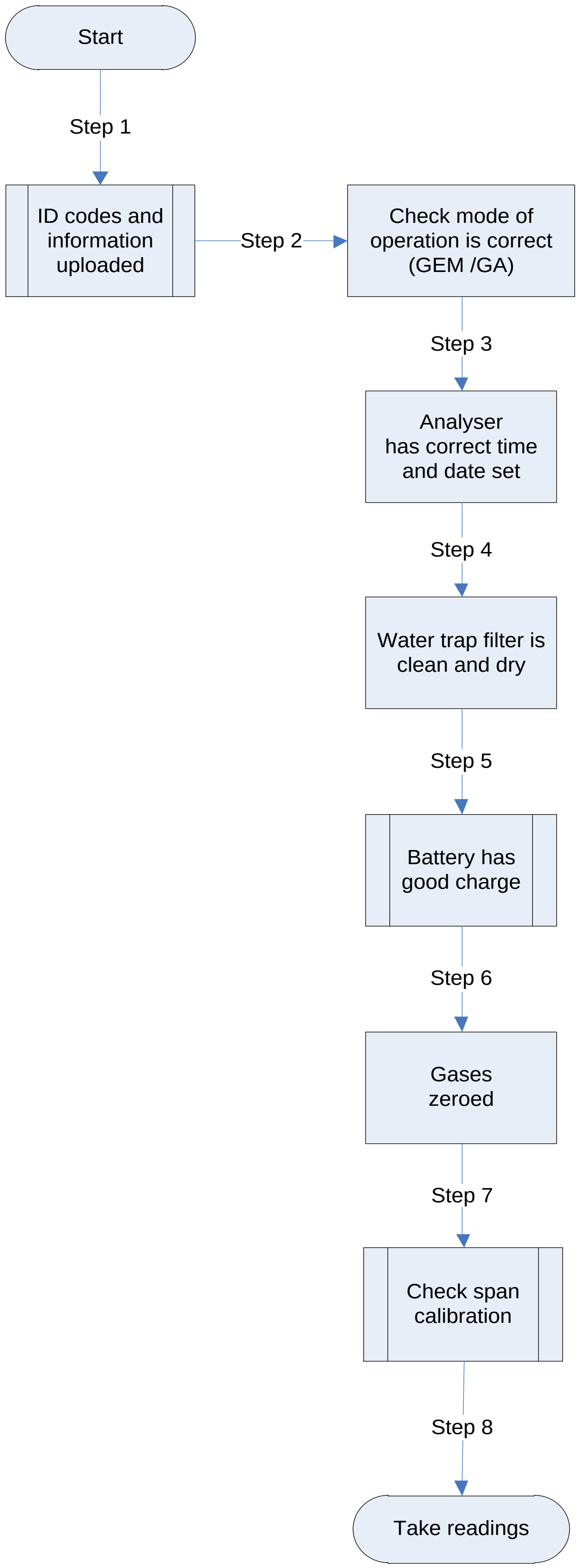
ATTACHMENT 2

Preliminary Checklist

(Excerpt from GEM5000 Gas Analyzer Operating Manual)

8.0 Taking Readings

8.1 Preliminary checks before taking readings (best practice)



Prior to use, it is good practice to ensure that:

Step 1 If using LSGAM - all necessary ID codes and information have been uploaded from LSGAM to the analyzer. Please see section 8.1.1 for more information on this.

Step 2 Check the 'Mode of Operation' is correct. Choose either GEM5000 for gas extraction monitoring analyzer or GA5000 for landfill gas analyzer. Change using 'Special Actions'.

Step 3 The instrument has the correct time and date set.

Step 4 The water trap filter is fitted and is clean and dry.

Step 5 The battery has a good charge (minimum 25% charge, even if only a few readings are required).

Step 6 The gas channels have been zeroed, without gas concentration present.

Step 7 If necessary check the span calibration with a known concentration calibration gas.

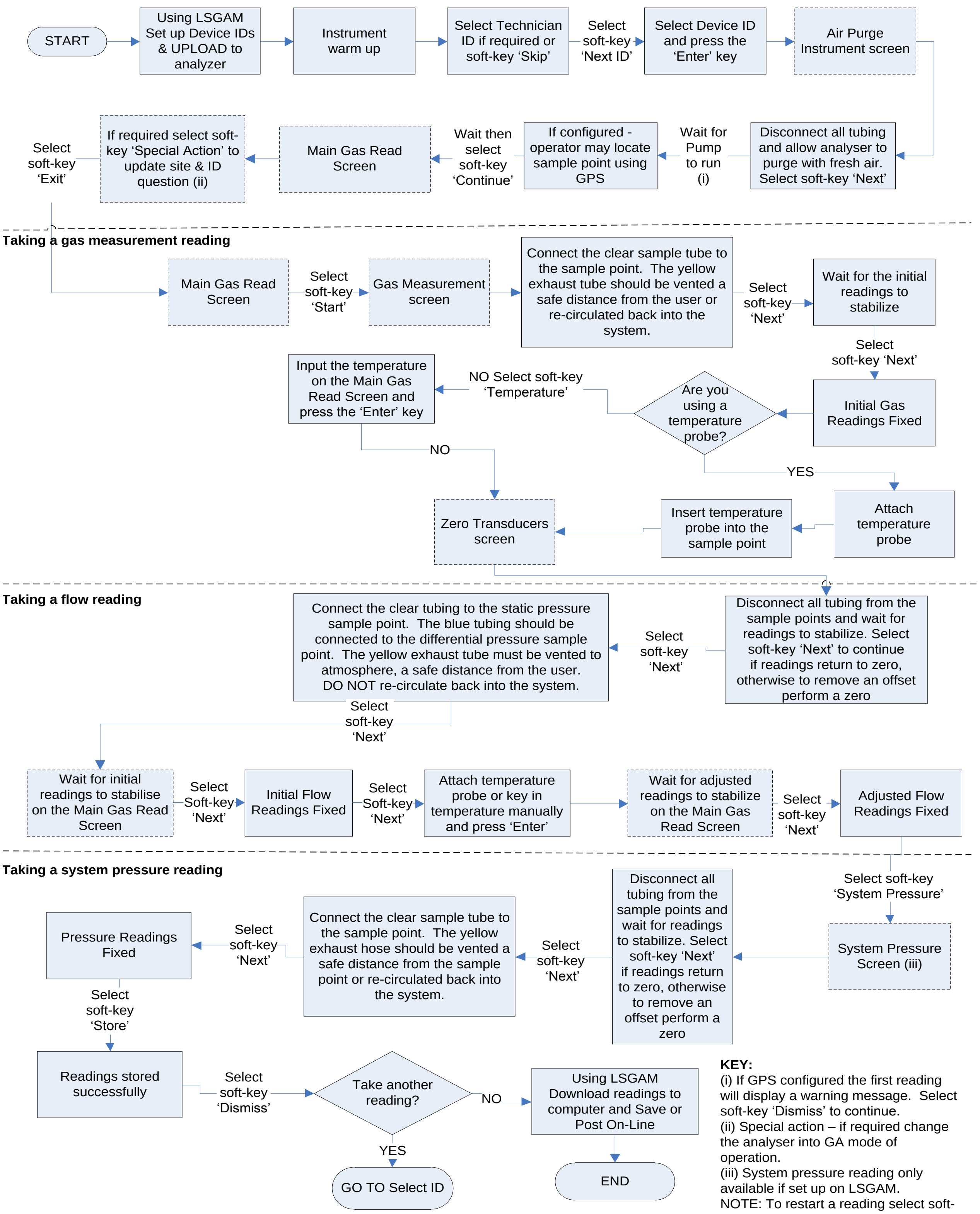
Step 8 Take readings.

ATTACHMENT 3

Sampling Flow Diagram

(Excerpt from GEM5000 Gas Analyzer Operating Manual)

8.8.5 Taking gas and flow measurement



KEY:
(i) If GPS configured the first reading will display a warning message. Select soft-key 'Dismiss' to continue.
(ii) Special action – if required change the analyser into GA mode of operation.
(iii) System pressure reading only available if set up on LSGAM.
NOTE: To restart a reading select soft-key 'Special Action' followed by key 1 'Restart Process'.

Attachment 2

Field Data Form

Lockwood Hills LLC
Lockwood Ash Disposal Site
Gas Generation Study

Field Crew: Ryan Elliott, Sam Daigler

Date: 6-15-2021

Weather: Cloudy, Slight breeze, rain earlier in the day

Sample Point	Purge Time and Volume (liters)	Analyte	Result	Units	Time
DW1	NA	CH4	0.2	%	9:28 am
DW1		CO2	0.1	%	"
DW1		CO	1	ppm	"
DW1		O2	21.1	%	"
DW1		H2S	0	ppm	"
DW1		Balance Gas	~~0.01~~ 78.7	%	"
DW1		Static Pressure	-0.01	" H_2O	"
DW1		Differential Pressure	0.001	" H_2O	"
DW1		H2	<0.01	%	"
DW1		Temperature	65.6	°F	"
DW1		Flow	9	mph	"
UW1	NA	CH4	0.2	%	9:52 am
UW1		CO2	0.1	%	"
UW1		CO	1	ppm	"
UW1		O2	21.2	%	"
UW1		H2S	0	ppm	"
UW1		Balance Gas	78.6	%	"
UW1		Static Pressure	-0.02	" H_2O	"
UW1		Differential Pressure	-0.007	" H_2O	"
UW1		H2	<0.01	%	"
UW1		Temperature	64.3	°F	"
UW1		Flow	9	mph	"
LW1 - Ambient	NA	CH4	0.2	%	10:25 am
LW1 - Ambient		CO2	0.1	%	"
LW1 - Ambient		CO	1	ppm	"
LW1 - Ambient		O2	21.2	%	"
LW1 - Ambient		H2S	0	ppm	"
LW1 - Ambient		Balance Gas	78.5	%	"
LW1 - Ambient		Static Pressure	-0.01	" H_2O	"
LW1 - Ambient		Differential Pressure	-0.002	" H_2O	"
LW1 - Ambient		H2	<0.01	%	"
LW1 - Ambient		Temperature	67.7	°F	"
LW1 - Ambient		Flow	7 mph	mph	"
LW1	17 min (4.69 L)	CH4	0.2 / 0.1*	%	11:30 am
LW1		CO2	1.4 / 0.7	%	"
LW1		CO	11 / 1	ppm	"
LW1		O2	19.4 / 20.5	%	"
LW1		H2S	0 / 0	ppm	"

* When measurements are separated by a dash "/" the first measurement is the initial measurement before purging and the second is the measurement taken after purging.

EnSol, Inc.

Lockwood Hills LLC
Lockwood Ash Disposal Site
Gas Generation Study

Sample Point	Purge Time and Volume (liters)	Analyte	Result	Units	Time
LW1		Balance Gas	78.5 / 78.6	%	"
LW1		Static Pressure	-0.02	" H_2O	"
LW1		Differential Pressure	-0.001	" H_2O	"
LW1		H2	<0.001 / <0.01	%	"
LW1		Temperature	66.1 / 66.3	°F	"
LW1		Flow	0 - 2.4	FPM	11:41 am
LW2 - Ambient	NA	CH4	0.2	%	12:00 pm
LW2 - Ambient		CO2	0.1	%	"
LW2 - Ambient		CO	1	ppm	"
LW2 - Ambient		O2	21.4	%	"
LW2 - Ambient		H2S	0	ppm	"
LW2 - Ambient		Balance Gas	78.4	%	"
LW2 - Ambient		Static Pressure	0.00	" H_2O	"
LW2 - Ambient		Differential Pressure	0.002	" H_2O	"
LW2 - Ambient		H2	<0.001	%	"
LW2 - Ambient		Temperature	66.8	°F	"
LW2 - Ambient		Flow	12	mph	"
LW2	17 min (4.69 L)	CH4	0.2 / 0.1	%	12:32 pm
LW2		CO2	0.9 / 0.8	%	"
LW2		CO	7 / 2	ppm	"
LW2		O2	20.4 / 20.8	%	"
LW2		H2S	0 / 0	ppm	"
LW2		Balance Gas	78.1 / 78.3	%	"
LW2		Static Pressure	0.01	" H_2O	"
LW2		Differential Pressure	0.003	" H_2O	"
LW2		H2	<0.01 / <0.001	%	"
LW2		Temperature	66.8 / 59.6	°F	"
LW2		Flow	0 - 5.4	FPM	12:39 pm
LW3 - Ambient	NA	CH4	0.2	%	1:31 pm
LW3 - Ambient		CO2	0.1	%	
LW3 - Ambient		CO	0	ppm	
LW3 - Ambient		O2	21.4	%	
LW3 - Ambient		H2S	0	ppm	
LW3 - Ambient		Balance Gas	78.4	%	
LW3 - Ambient		Static Pressure	0.01	" H_2O	
LW3 - Ambient		Differential Pressure	0.00	" H_2O	
LW3 - Ambient		H2	<0.01	%	
LW3 - Ambient		Temperature	67.3	°F	
LW3 - Ambient		Flow	12	mph	
LW3	17 min (4.69 L)	CH4	0.2 / 0.2	%	2:00 pm
LW3		CO2	0.4 / 0.5	%	"
LW3		CO	13 / 1	ppm	"

Lockwood Hills LLC

Lockwood Ash Disposal Site

Gas Generation Study

Sample Point	Purge Time and Volume (liters)	Analyte	Result	Units	Time
LW3		O2	18.0 / 18.6	%	"
LW3		H2S	0 / 0	ppm	"
LW3		Balance Gas	81.4 / 80.8	%	"
LW3		Static Pressure	0.01	"H_2O	"
LW3		Differential Pressure	-0.001	"H_2O	"
LW3		H2	<0.01 / <0.001	%	"
LW3		Temperature	59.7 / 57.2	°F	"
LW3		Flow	0-5.9	FPM	2:12 pm
LW4 - Ambient	NA	CH4	0.2	%	2:38 pm
LW4 - Ambient		CO2	0.1	%	"
LW4 - Ambient		CO	1	ppm	"
LW4 - Ambient		O2	21.2	%	"
LW4 - Ambient		H2S	0	ppm	"
LW4 - Ambient		Balance Gas	78.6	%	"
LW4- Ambient		Static Pressure	0.003	"H_2O	"
LW4 - Ambient		Differential Pressure	-0.001	"H_2O	"
LW4 - Ambient		H2	<0.001	%	"
LW4 - Ambient		Temperature	79.2	°F	"
LW4 - Ambient		Flow	8	mph	"
LW4	17 min (4.69 L)	CH4	0.2 / 0.1	%	3:04 pm
LW4		CO2	1.0 / 0.8	%	"
LW4		CO	4 / 2	ppm	"
LW4		O2	20.2 / 20.2	%	"
LW4		H2S	0 / 0	ppm	"
LW4		Balance Gas	78.6 / 78.9	%	"
LW4		Static Pressure	~~0.002~~ 0.02	"H_2O	"
LW4		Differential Pressure	0.002	"H_2O	"
LW4		H2	<0.01 / <0.001	%	"
LW4		Temperature	78.0 / 80.9	°F	"
LW4		Flow	5.2	FPM	3:15 pm
DW2	NA	CH4	0.2	%	3:57 pm
DW2		CO2	0.0	%	xx
DW2		CO	1	ppm	xx
DW2		O2	21.1	%	"
DW2		H2S	0	ppm	"
DW2		Balance Gas	78.7	%	"
DW2		Static Pressure	0.03	"H_2O	"
DW2		Differential Pressure	-0.004	"H_2O	"
DW2		H2	<0.01	%	"
DW2		Temperature	82.0	°F	"
DW2		Flow	7 mph	mph	"

Lockwood Hills LLC
Lockwood Ash Disposal Site
Gas Generation Study

Notes:

Soil/Waste Characterization LW1: (OADS) Mixture of grasses & crown vetch, topsoil, fill for final cover system (light brown soil), Coal ash starting around 2 ft until bottom of borehole at 3.5 ft grey

Soil/Waste Characterization LW2: (Overfill) Reed canary grass cover, intermediate fill, less gravelly than LW1, 2.25 ft starting to turn gray, hit ash - grey around 2.5 ft, starts to get wet in last 0.5 ft, drier again below

Soil/Waste Characterization LW3: (Stage 2) Grasses & crown vetch cover, ~1.1 ft of cover soils, black ash after ~1.1 ft until bottom of borehole

Soil/Waste Characterization LW4: (Stage 1 2019 Disposal Area) Substantially different grass cover than other locations w/ clovers, Light brown gravelly cover soil until ~2 ft, ash material more clay like than either ash type encountered, most similar to LW1, more black than grey near bottom of hole

- No flow could be felt through PVC w/ hand placed over top of pipe
- Flow would typically start @ 0 FPM & slowly increase

GPS Coordinates:

DW1: 42° 40' 27.1", -76° 57' 33.6"
UW1: 42° 40' 18.0", -76° 57' 47.2"
LW1: 42° 40' 27.4", -76° 57' 39.8"
LW2: 42° 40' 26.7", -76° 57' 39.5"
LW3: 42° 40' 20.6", -76° 57' 39.8"
LW4: 42° 40" 21.6", -76° 57' 43.5"
DW2: 42° 40" 17.1", -76° 57' 35.3"

EnSol, Inc.

GEM 5000 Plus

FIELD ENVIRONMENTAL INSTRUMENTS, INC.

www.fieldenvironmental.com

301 Brushton Ave
Suite A
Pittsburgh, PA 15221
Toll Free (800) 393-4009
Local (412) 436-2600
Fax (412) 436-2616

Landtec Landfill Meter Calibration Certificate

Fresh Air	Reading %	Acceptable Range
Oxygen	20.9	(20.65% - 21.15%)

	Lot #	Expiration
Cal Standard	20-7696	2/17/2025

		Reading %	Acceptable Range
Methane	15%	15.0	(14.7% - 15.3%)
Carbon Dioxide	15%	15.0	(14.5% - 15.5%)

	Lot #	Expiration
Cal Standard	20-7654-25	1/26/2023

		Reading %	Acceptable Range
Carbon Monoxide	50 ppm	50.0	(51 - 49)
Hydrogen Sulfide	25ppm	25.0	(24 - 26)

Model	GEM-5000+
S/N	G500846
Barcode	U71054X
Order #	456741

Calibrated By: Zach Crawford

Date of Calibration: 06/03/21

All calibrations performed by Field Environmental Instruments conform to manufacturer's specifications.
All calibration gas used is traceable to NIST. Additional documentation is available upon request.

Hydrogen Meter

H2scan

Hydrogen is the future, we can sense it!

Certificate of Conformance

Manufacturer:

Name: *H2scan Corporation*
Address: 27215 Turnberry Lane, Unit A
Valencia, California 91355 USA
Phone: (661) 775-9575 Fax: (661) 775-9515

Product Declaration:

DATE:	September 14, 2020
PART NUMBER:	100500
MODEL:	500
MODEL SN:	A000285
SENSOR SN:	B12.07RB.00194STDHC
CHARGER SN:	150902
FIRMWARE REVISION:	S1.72/C1.27
SO# / PO#	**10898 / 433262**

Requirements this product is in Conformance with at time of manufacture:

	Initials
Inspected per: H2scan procedures & drawings.	JL
Tested per: H2scan procedures & specifications.	JL
Calibrated per: H2scan procedures & specifications.	JL
Calibration Gasses: Traceable to NIST standards.	JL

Authorized Quality Representative:

Quality Representative: Jim Litton

Signature: James Litton

Date: September 14, 2020

www.h2scan.com

Acceptance Test

H2scan Corporation
27215 Turnberry Lane, Suite A
Valencia, CA 91355
(661) 775 - 9575

Model: **500**

Assembly Serial Number: **A000285**

Sensor Serial Number: **B12.07RB.00194STDHC**
Sales Order Number **10898**

Sensor Temp, °C: **95**

Background Gas: **Air**

Hydrogen Concentration [H2% by vol.]	Indication Pass/Fail	LED Array Pass/Fail	LCD Bars Pass/Fail	Keypad Pass/Fail
0.0	P	P	P	P
0.0	P	P	P	
0.1	P	P	P	
2.0	P	P	P	
5.0	P	P	P	

GASES USED IN CALIBRATION HAVE BEEN CERTIFIED USING INSTRUMENTATION TRACEABLE TO THE NIST www.h2scan.com

H2scan Corporation
27215 Turnberry Lane, Suite A
Valencia, CA 91355
(661) 775 - 9575

WRS Sensor S/N **B12.07RB.00194STDHC**
Sensor PCBA S/N **8L1044-21**
Sales Order Number **10898**

Sensor Op. Temp. [°C] **95**
Background Gas **Air**

85000012 R12, 12/17/15
500 Traveler

Acceptance Test Procedure													By	Date
Record Manufacturing Procedure Revision (86000012)					2		Record Firmware Revision				0.00			
Room Temperature [°C]											24.7		KM	9/14/20
Cylinder S/N	**Cylinder H2% Conc**	**Pressure [psia]**	**Exposure Time (min)**	**Press.Comp. H2% Conc**	**LED Array**	**P/F LED Array**	**LCD Bars**	**P/F Bars**	**<H2% or Indicated**	**Error**	**Tolerance**	**P/F H2%**		
9/14/2020 9:10	**0.0000**	**14.198**	30	0.0000	**0**	P	**0**	P	**< 0.001**			P		
9/14/2020 9:15	**0.0098**	**14.198**	5	0.0095	**0**	P	**3**	P	**< 0.01**			P		
9/14/2020 9:23	**0.1010**	**14.198**	5	0.0976	**1**	P	**5**	P	**< 0.1**			P		
9/14/2020 9:28	**1.9760**	**14.197**	5	1.9089	**3**	P	**11**	P	**2.1**	0.1911	0.3573	P		
9/14/2020 10:33	**4.9950**	**14.197**	5	4.8254	**3**	P	**12**	P	**5.1**	0.2746	0.4448	P	KM	9/14/20

Comments	

Keypad Test Procedure					By	Date
Steps after ATP	**Keypad**	**LCD Display**	**Record Unit Firmware / Serial Number**	**P/F**		
1	ENTER	Information Disp		P		
2	right	Firmware Rev S1.XX /C0.XXX	S1.72/C1.27	P		
3	down	Serial Number: A000XXX	A000285	P		
4	up up	Calibration Date XX/XX/XX		P		
5	left	Information Disp		P	KM	9/14/20

ATP, RMA4297 500HH

Attachment 3

Representative Photographs

Photo #1 - Sample Point LW3 Pre-Disturbance

Photo #2 - Sample Point LW4 Soil/Waste Characterization During Augering

EnSol, Inc.
Environmental Solutions
661 Main Street, Niagara Falls, NY 14301
Ph:716-285-3920 Fax: 716-285-3928

GAS SAMPLING

LOCKWOOD HILLS LLC
590 PLANT ROAD P.O. Box 187
DRESDEN, NY 14441

PROJECT PHOTOGRAPHS

Prepared By: RJE
Date Prepared: 6/17/21
Filename: Site Photos.xls

LANDFILL GAS GENERATION STUDY

PN: 21-0002-05b June 2021

Photo #3 - Sample Point LW2 Gas Composition Sampling

Photo #4 - Sample Point LW2 Gas Flow Sampling

EnSol, Inc.
Environmental Solutions
661 Main Street, Niagara Falls, NY 14301
Ph:716-285-3920 Fax: 716-285-3928

GAS SAMPLING
LOCKWOOD HILLS LLC
590 PLANT ROAD P.O. Box 187
DRESDEN, NY 14441

PROJECT PHOTOGRAPHS

Prepared By: RJE
Date Prepared: 6/17/21
Filename: Site Photos.xls

LANDFILL GAS GENERATION STUDY

PN: 21-0002-05b June 2021

Attachment 4

Works Cited

Works Cited

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