September 2015

GUIDANCE DOCUMENT

METHANE MONITORING AT SOLID WASTE DISPOSAL FACILITIES

LEGAL AUTHORITY:

Rules of Solid Waste Management
391-3-4-.07(3)(h)
391-3-4-.07(4)(c)4

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INTRODUCTION

The purpose of this document is to provide the regulated community with guidance in the design of methane monitoring plans and systems. Methane monitoring plans must include: Methane monitoring system design, sampling, and reporting protocols for the routine monitoring of explosive gases (methane) at solid waste disposal facilities in Georgia. Methane monitoring is required at:

- All permitted Municipal Solid Waste Landfill Facilities (MSWLF)in Georgia that accepted waste after June 29, 1991,
- All MSWLF that cannot demonstrate the facility was properly closed prior to June 29, 1991 And
- Inert Landfills that have accepted organic materials

The Rules of Solid Waste Management, Chapter 391-3-4.07 (Rules) require that facilities comply with performance standards that are protective of human health and the environment. To meet these requirements, the Environmental Protection Division (EPD) developed minimum standardized procedures to design the methane monitoring systems and to collect and evaluate the data from these systems. These standard procedures are discussed in this document.

This document contains five sections:

Section 1 is an overview of what is landfill gas, how it behaves, and why it must be monitored at landfills.

Section 2 discusses the design of methane monitoring systems, and specifies the minimum information that EPD expects a facility, or its consultant, to gather and evaluate prior to designing a monitoring system to detect effectively the offsite migration of methane in the subsurface. For reference purposes, Appendix A includes the Methane Monitoring Plan Review Checklist that EPD staff will utilize to review methane plan submittals.

Section 3 describes monitoring protocols.

Section 4 describes the monitoring–schedules and reporting protocol. The Periodic Methane Monitoring Report, designated SWM-19, is included in its entirety in Appendix B for reference.

Section 5 includes a brief overview of remedial measures that can be implemented to address methane migration. Appendix C is an excerpt from the RCRA Subtitle D Training Manual (Section 4.5) which includes more detailed discussions of methane migration remedial measures. Appendix D is EPD Form SWM-20 Methane Gas Recovery/Venting Systems, which outlines the minimum information that must be provided for in-waste gas system design.

SECTION 1: LANDFILL GAS

Landfill gas is predominantly composed of methane and carbon dioxide. Due to methane's explosive nature at concentrations between 5% and 15% by volume (lower explosive limit (LEL) and upper explosive limit (UEL), respectively); methane gas monitoring is required at solid waste disposal facilities, unless otherwise exempted.

Above 15%, methane gas will neither burn, nor explode, as the concentration is too rich. Landfill gases will also kill vegetation by reducing the oxygen concentration in the soils. Asphyxiation in confined spaces can result from the higher concentrations, since the landfill gases can displace oxygen. OSHA defines oxygen-deficient levels as those below 19.5% by volume. Certain methane meters will not function in oxygen-deficient environments; therefore EPD recommends oxygen monitoring to ensure accurate methane monitoring results.

Methane generation is dependent upon a number of factors, predominantly the presence of oxygen, the age of waste, and the moisture content of the waste. The presence of oxygen will reduce methane generation, while increased moisture content will increase methane generation. While capping landfills (both intermediate cover materials and final closure) will reduce infiltration and eventually reduce moisture content, placement of a cap on a landfill without an adequate venting system will result in an increased potential for landfill gases to migrate laterally.

Landfill gas will migrate via three mechanisms – concentration, density, and pressure gradients. Methane itself is lighter than air and will tend to migrate upwards; however, when migrating with other denser gases (such as carbon dioxide) migration direction can vary. Landfill gases will tend to migrate along the path of least resistance, from zones of higher barometric pressures to zones of lower pressure as weather conditions vary. Gases will migrate along the most permeable zones in the subsurface and along man-made permeable zones, such as sewer lines, underground cables, water lines, gas lines, etc.

Rather than allow for the upward movement of gases through the unsaturated zone, as one would expect, the fining upwards of soils in the Piedmont can prevent upward gas migration and increase the likelihood of horizontal migration in the deeper partially weathered rock zones,. The rate of migration can be increased significantly with the introduction of large volumes of water percolating into the landfill from precipitation events and freezing soil conditions that create an impermeable layer at the surface. It is EPD's opinion that monitoring can and needs to be performed after large storm or severe weather events, to simulate worse case scenarios for potential migration. Monitoring needs to be performed when subsurface gas pressures are highest, usually in the early afternoon.

Additional information regarding the potential health effects of landfill gases can be found in the Agency for Toxic Substances and Disease Registry's document entitled "Landfill Gas Primer An Overview for Environmental Health Professionals", available online at:

http://www.atsdr.cdc.gov/HAC/landfill/html/intro.html

SECTION 2: DESIGN OF METHANE MONITORING SYSTEMS

While each solid waste disposal facility has its own unique environmental and surrounding land use setting, a consistent approach must be taken in the development of the design of the methane monitoring system. Most disposal facilities have received organic materials that will result in the generation of methane. All Municipal Solid Waste Landfills (MSWLs) and Construction/Demolition Landfills (which are a sub-category of MSWL's) are required to develop methane monitoring programs to detect offsite methane migration, regardless of the adjacent land usage. Newly permitted inert landfills are also required to perform methane monitoring. Many Industrial Landfills are required to perform methane monitoring, if their waste streams included materials that generate methane. Industrial landfills that have been deferred from methane monitoring are required to notify EPD whenever their waste streams change.

The depth and number of monitoring locations will be based on a hydrogeologic assessment of the site. In areas where landfills are sited in communities with adjacent structures, the number of methane monitoring locations needs to be increased accordingly. If adjacent or adjoining property usage changes, methane monitoring systems are to be revised to ensure the safety of adjacent/adjoining residents and/or workers. The entire unsaturated zone, from approximately 4 feet below ground surface to the top of the saturated zone or to the top of competent rock, is required to be monitored[1].

A Georgia registered professional geologist (PG) or professional engineer (PE) must design a methane monitoring plan for a facility. This is usually done while developing a Design and Operational (D&O) Plan for a facility. If the plan is not part of a comprehensive D&O Plan set, or a change to an existing plan is being requested or has been required by EPD, a completed minor modification request form must accompany the plan submittal. Four (4) copies of the plan and 1 copy of the supporting data need to be provided for review and approval. The design of this plan must be based on the results of a hydrogeologic assessment which has been prepared by a PG/PE who is certified as a qualified groundwater scientist. This information needed to develop a Methane Monitoring Plan is generally available for most existing facilities, either from the original site suitability reports or from the development of the groundwater monitoring system for the facility. Current water table information must be used for the design, or in a re-evaluation, of a methane plan/system for a site. Groundwater data can be obtained using the most recent water table readings reported in the groundwater monitoring semiannual reports. For those facilities that do not monitor groundwater, the owner/operator must demonstrate to EPD that the methane monitoring system at their facility will adequately detect subsurface methane migration.

The primary subsurface information relevant to the design of the Methane Monitoring Plan is the depth to the water table (potentiometric surface) and the characteristics of the soils and lithologies above this surface. In some instances, the water table will be below the top of competent rock; a PG/PE must evaluate this scenario to determine where and how methane monitoring locations need to be installed to effectively detect landfill gas migration. If confined aquifer systems are present, a PG/PE must design the methane monitoring network to monitor the entire interval above the upper confining unit of the aquifer, rather than base the system design on depth to water alone. In areas where perched water zones exist, the PG/PE is required to consider monitoring both above and below the perched zones. In some scenarios, the maximum depth of waste is a factor to be considered in determining the depth of a methane monitoring well screen.

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[1] In areas of Georgia where depth to water is excessive (>100'), EPD may waive this requirement, provided the PG/PE responsible for development of the plan has provided a defensible rationale that is based on both the geology and hydrogeology of the site. When preparing this plan, legible cross-sections must be provided that clearly show lithologies, depths to water and waste units. The PG/PE must be able to demonstrate to the satisfaction of the Director that gas will not migrate at depth in these scenarios. Merely stating that a facility has a liner system will not suffice as a demonstration.

EPD expects that methane wells[2] will be constructed at most facilities. On a case-by-case basis, where the depth to water or the top of competent rock is less than 8 feet below ground surface, barhole punches (or other alternative shallow monitoring protocols) may be acceptable, but a PG/PE must demonstrate that these shallow methods of landfill gas detection are appropriate. In general, most barhole punches are only 3 feet in length, so the use of these monitoring locations needs to be limited to very shallow water table or shallow competent rock conditions.

It is incumbent upon a PG/PE working for the owner of the facility, to demonstrate that the methane monitoring system installations meet the all the criteria listed above.

METHANE GAS MONITORING WELL CONSTRUCTION

Methane monitoring wells are to be constructed of commercially available, 1-inch or 2-inch inside diameter, flush-threaded, Schedule 40 PVC casing (riser) and Number 10-20 slot (0.010-0.020 inch) screen or 1/8 inch machine slotted holes. Field slotting is not allowed. The PVC screen and riser are constructed of materials which are chemically and physically stable. It is recommended screened intervals not exceed 25 feet in length[3]. If multiple wells are to be installed in the same borehole at different elevations, a minimum of 5 feet of hydrated bentonite is required to separate the screened/filter packed intervals.

The filter packs are to be constructed with commercially available, chemically inert, well-rounded, dimensionally stable, pea gravel. The filter pack will extend to the top of the well screen, topped by six inches of coarse sand. One (1) foot of chemically inert hydrated bentonite pellets/chips or bentonite slurry will be used to seal the annular space above the filter pack. A cement and bentonite mixture, a minimum 3 feet in length is required above the bentonite seal. A mounded concrete pad with a minimum radius of two foot and four inches thick (a 4'x4'x4" pad) is to be constructed at the surface. The PVC well cap will be equipped with a quick-connect for sampling; the quick-connect needs to be sealed between events. A protective steel stand-up cover with keyed lock and weep hole will be installed around the above ground well casing; the void between the steel cover and the PVC riser needs to be backfilled with pea gravel. It is good practice to have all wells keyed alike. A set of keys needs to be kept onsite.

The filter pack, sand, and bentonite pellets are generally emplaced with a tremie pipe, however they may be placed around the screen/casing by dropping the materials directly down the borehole provided a tamping device is used to reduce the potential for bridging. The cement-bentonite mixture will be prepared using potable water and placed in the borehole using a tremie pipe.

The design and construction of methane gas monitoring wells will be documented on well completion logs, which will show "as-built" construction (Figures 1 & 2). A driller bonded in accordance with the Georgia Water Well Standards Act (WWSA) must install the wells**.** The minimum information that needs to be provided is listed below. Construction needs to be certified by a PG/PE as being constructed in accordance with approved plan, with any deviations noted and clearly justified. A table needs to be included with the "as-built" construction documentation with the well depths, screened interval elevations (Table 1), estimated groundwater and surveyed ground surface elevation included on the table. Surveyed vertical and horizontal control data must be provided for all methane monitoring locations, both wells and barhole punches or other shallow sampling methods. The following information will be provided in report format signed/sealed by the responsible PG/PE for the documentation of methane well construction:

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[2] EPD uses the word well in regard to permanent methane monitoring features installed by drilling. As such, any individual installing methane wells must be bonded in accordance with the Georgia WWSA, and the wells needs to be inspected by a PG/PE every five years.

[3] Limiting screen lengths to 25 feet will allow the professional to isolate the potential zone of gas migration, and assist in choosing appropriate remedial measures – for example, if gas migration is determined to be greater than 25 feet in depth, cut off trenches will not likely be an effective remedial alternative.

1. Lithologic/boring logs
2. Site monitoring location map with all monitoring locations surveyed to +/-.5 feet sealed by surveyor and responsible PG/PE
3. Top of casing elevation
4. Ground surface elevation
5. Screened interval depths and elevations of top and bottom of screen
6. Well construction materials –
    a. casing
    b. filter pack
    c. grout
    d. sand
    e. bentonite seal
    f. pad size and thickness
    g. protective casing
7. Well construction material volumes
8. Well construction material placement methods
9. Drilling method
10. Driller name
11. Copy of driller's bond
12. Individual well details for each well, signed and sealed by the Georgia PG/PE responsible for installation.

BARHOLE PUNCH MONITORING LOCATIONS

EPD discourages the use of barhole punches for methane monitoring. Barhole punch monitoring locations should **only** be considered where the water table or competent rock is within 8 feet of the ground surface. It has been EPD's experience that it is very difficult to obtain consistent, representative samples of landfill gas from barhole punch monitoring locations, most likely due to air intrusion. During sampling of barhole locations, EPD has obtained significantly different results from operators and consultants, sampling the same hole at the same time. In most scenarios, barhole punches are not appropriate for demonstrating compliance, particularly where groundwater is deep and less permeable layers (such as silty clays) are close to the surface.

A barhole punch is formed by driving a 1/2 inch diameter steel rod 3-5 feet into the ground during each monthly or quarterly sampling event. It is NOT acceptable to reuse the same punch hole each sampling event. A fresh hole needs to be driven each sampling event. Barhole punch locations can **never** be retrofitted with PVC casings into "temporary" wells. If a permanent well is needed at a location then one needs to be installed properly as described above. The use of a hand power auger to drill sampling points is not considered a barhole punch.

ALTERNATIVE MONITORING POINT METHODOLOGIES

EPD will consider the use of monitoring points installed in accordance with EPA Region 4 SESDPROC-307-R2, soil gas sampling, which can be found at EPA Region 4 Field Branches Quality System and Technical Procedures, or a more recent version if applicable. These alternative monitoring points must also be installed under the supervision of a Georgia registered PG/PE.

MONITORING LOCATION SPACING

EPD generally requires methane monitoring points along the facility property boundary, with a spacing ranging 300-500 feet between methane monitoring locations, depending on the waste type being disposed of at the facility. The spacing for construction/demolition and some industrial waste disposal sites may be broader due to the lower potential for methane generation. MSWL methane monitoring points are usually spaced 300 – 400 feet apart. At sites where there are adjacent or adjoining structures within 500 feet of the waste unit, the spacing must be modified to ensure monitoring between the waste mass and each nearby structure. Where features exist that will preclude migration offsite (such as perennial streams), monitoring may not be required, but the PG/PE developing the Methane Monitoring Plan must prove where these conditions exist.

If the property usage of the adjacent/adjoining the sites changes, the monitoring systems will require a review by a PG/PE and, potentially, a modification.

MONITORING LOCATIONS

The purpose of a methane monitoring system is to determine whether methane is migrating in the subsurface outside the permitted facility property boundary. As such, methane wells are to be constructed between the waste mass and site boundary. Some facilities prefer to locate the methane wells closer to the waste mass to try to determine if there is a migration problem before it reaches the boundary. Regardless of the location of the monitoring points, EPD will treat all methane detections in the approved methane monitoring system as methane migration at the facility property boundary, and will expect the owner/operator of the facility to initiate the implementation of corrective action immediately.

ESTABLISHING MONITORING LOCATIONS, DESIGNATIONS AND MARKERS

All monitoring locations (wells and barhole punches) need to be surveyed (location and elevation). An as-built site monitoring location map that includes all monitoring locations needs to be developed and provided to EPD. Permanent markers need to be established at all monitoring locations. Well identification can be labelled on the protective well casing, on signs placed on 4"x4" posts, or on t-posts located adjacent to the well identifying each monitoring location. The Methane Monitoring Plan will include a description of the type of markers to be used. Methane monitoring locations are usually designated in the following manner: MM-1, MM-2, sequentially around the perimeter of a site. Structural monitoring points (further discussed on page 7 in this guidance document) may receive a numeric designation, or simply be referred to by the structure's name.

METHANE MONITORING PLAN SUBMISSION

A minor modification request form must be submitted if a Methane Monitoring Plan is being developed separately from the initial D&O Plans required for the facility, if the plan is being modified, or if a remediation plan is being developed. The minor modification form must be filled out in its entirety by the owner/operator. The Methane Monitoring Plan Review Checklist in Appendix A lists the elements that need to be included in the submittal of a Methane Monitoring Plan.

Methane Monitoring Plan submissions needs to be submitted directly to the Environmental Monitoring Compliance Unit of EPD's Solid Waste Management Program.

METHANE MONITORING SYSTEM AS-BUILT CONSTRUCTION SUBMITTALS

As-built documentation reports are required to be submitted to EPD within 45 days of well installation. All the items listed on page 4 of this guidance document need to be included in the report. Facilities must install replacement methane wells within 60 days of noting that a well has been damaged or destroyed.

SECTION 3: LANDFILL GAS MONITORING PROCEDURES

METHANE GAS MONITORING WELLS

- Plan to sample methane monitoring wells between 12:00 pm and 6:00 pm, when subsurface gas pressures are generally highest;
- Check weather and barometric pressure (<u>do not sample if it is raining</u>) immediately when arriving to the site;
- Calibrate the meter in accordance with manufacturer specifications;
- At each well, unlock the protective casing. Do not remove the well cap, wells need to be retrofitted with caps with either quick connects or gas nozzle fitting compatible with your

meter intake. If the well has not been retrofitted, remove the well cap and immediately insert the hose into the opening approximately 18 inches and seal the well opening around the sample hose to prevent both potential loss of accumulated gases and intrusion of ambient air. The well needs to be retrofitted with a quick connect prior to the next sampling event.[4] **Wells should not be allowed to vent any period of time prior to monitoring.** If groundwater monitoring wells are being utilized for methane sampling, the vent hole in the PVC casing needs to be temporarily sealed and a quick connect cap needs to be placed on the well to ensure ambient air is not pulled into the well;

- Pump the sample into the meter per manufacturer specification to obtain a representative sample for a minimum of 3 minutes;
- Record the peak reading[5] on the meter;
- Replace the well cap or close the quick connect/disconnect valve (unblock the vent hole in a groundwater monitoring well) and relock the protective casing;
- Proceed to next well or barhole punch location.

BARHOLE PUNCHES

Barhole punch monitoring procedures are similar to those used in sampling landfill gas monitoring wells, except a new sampling point has to be "created" or punched prior to each sampling event. At each monitoring location, a small hole ½-inch in diameter and 3 to 5 feet deep will be formed with a barhole punch.

Procedures for preparing and sampling a barhole punch location are as follows:

- Arrive at site, check weather and barometric pressure (if it is raining do not sample);
- Calibrate the meter in accordance with manufacturer specifications;
- Using the barhole punch, drive the bar into the ground 3 to 5 feet;
- Remove the bar carefully and plug the hole with a stopper or seal to confine the headspace;
- Allow the gases in the hole to equilibrate approximately 30 – 60 minutes prior to sampling. (Note: if several barhole punches are to be performed, other holes may be prepared during the time of the equilibration period);
- Ensure it is after 12:00 pm but before 6:00 pm;
- Remove the stopper and immediately insert the sample hose into the hole. Seal the hole opening around the sample hose to prevent the loss of gases;
- Pump the sample into the meter per manufacturer specification to obtain a representative sample for a minimum of 60 seconds or until readings have stabilized;
- Record peak reading[5] on the meter;
- Proceed to next well or barhole punch location.

[4] Quick connects are not to include filtration devices installed in them, this impedes the flow of gas into some meters, shutting them down if flow rates are too low, potentially damaging the meter.
[5] EPD has decided to take a conservative approach in regard to sampling. Testing the accumulated methane in a well is, in EPD's opinion, the best way to ensure the safety of the public and citizens of Georgia.

MONITORING FOR LANDFILL GASES IN ON-SITE STRUCTURES

Routine landfill gas monitoring will include screening of on-site structures for gas accumulation. Monitoring may be performed by sampling air inside structures with the same equipment used to sample landfill gas monitoring wells or by using continuous gas detectors/alarm systems. If continuous gas detectors/alarm systems are used, detectors must be checked during the quarterly methane events to ensure proper operation and results submitted on EPD Form SWM-19. Methane levels in structures cannot exceed 25% of the lower explosive limit (LEL) for methane (1.25 percent by volume).

Recommended sampling locations within structures include: basements, crawl spaces, near ceilings on lower floors, and around subsurface utility lines (e.g. electrical conduit, plumbing, drains). Sampling of structures needs to be done after the structure has been closed for the weekend or overnight. The sampler should record the percent landfill gas and percent LEL on EPD Form SWM-19 for structures sampled. EPD also recommends monitoring adjacent structures within 300 feet of the landfill where methane migration has been confirmed to have migrated offsite. Inexpensive meters are available to meet these requirements.

ROUTINE SURVEY FOR VEGETATIVE STRESS

Physical observations for indications of landfill gas migration must be included in the routine landfill gas monitoring procedure. The landfill and surrounding areas need to be observed for physical signs of landfill gas migration including dead or dying grass and trees. Results of any observations are reported on EPD Form SWM-19 and submitted with routine monitoring results.

MONITORING EQUIPMENT

EPD requires the use of a meter that will work in an oxygen-deficient atmosphere, as methane and other gases (predominantly carbon dioxide) will displace oxygen in the subsurface. Some meters that depend upon a flame to determine the concentration of methane will not operate properly in an oxygen-deficient environment. High carbon dioxide levels may affect readings for those meters that use a thermal filament. It is highly recommended that facilities using these types of meters also report carbon dioxide levels. If detected methane gas levels exceed 60%, EPD will request carbon dioxide monitoring be reported to assist in demonstrating the results have not been affected by the presence of carbon dioxide.

EPD requests a copy of the monitoring equipment owner’s manual be provided by the owner/operator. If the monitoring equipment owner’s manual is available on the manufacturer’s webpage, the facility need only provide the webpage address. Meters used for methane monitoring in Georgia MUST, at a minimum, be able to read methane concentrations in both percent by volume 0 – 100% methane and percent LEL. EPD will not accept the use of meters that the manufacturer has specifically indicated are not appropriate for landfill usage (such as the Bacharach Model H).

MONITORING LOCATION INTEGRITY

The physical condition of the methane monitoring locations needs to be noted in the routine SWM-19 reports (presence/absence of appropriate markers/labels, access, condition of well locks, etc.) during each event. The locations are required to be maintained in accordance with the approved Methane Monitoring Plan for the facility.

SECTION 4: MONITORING SCHEDULE AND REPORTING

MONITORING SCHEDULE

Methane monitoring is required to be performed, at a minimum, quarterly [quarterly is considered to be the following: January-March (first quarter), April-June (second quarter), July-September (third quarter), and October-December (fourth quarter)]. Results need to be submitted to EPD within 14 days of the event. If results indicate methane has been detected above the lower explosive limit (LEL – greater than 5% by volume), monitoring should then be performed monthly. It is recommended the entire monitoring system be tested during these monthly events, not just the monitoring point where the LEL was exceeded. EPD may approve returning to quarterly monitoring after methane concentrations below the LEL have been measured, and reported to EPD, for a period of six consecutive months.

DOCUMENTATION OF AN EXCEEDANCE

If during the course of sampling, an exceedance of the LEL (greater than 5% methane by volume, in monitoring wells or bar punches, or 25% the LEL in structures) is measured, the owner/operator must notify EPD immediately, and place a copy of the results in the operating record of the facility within seven days of the exceedance. The facility is also required to immediately take all necessary steps to ensure protection of human health. At a minimum, to ensure public safety, no smoking signs need to be clearly posted around the areas where exceedances have been documented. Evacuation of structures with exceedances should be considered. Notification of local authorities may also be warranted at facilities that are located in urban settings. Public access to the facility is to be limited until the exceedance has been resolved.

To confirm an exceedance reading, the owner can and should resample immediately. If the owner determines his meter is malfunctioning and needs to rent a new meter, the owner may sample the next day using the rented meter. However, once it is determined that a meter malfunctioned, all monitoring locations need to be resampled. If a confirmation sample is not taken within **seven** days, EPD will assume that the initial reading was valid.

In situations where the monitoring location is not located at the facility property boundary, the owner/operator may conduct additional monitoring to demonstrate compliance at the property boundary. The demonstration needs to be attached to the SWM-19 report and include **comparative elevations** from the permanent and temporary monitoring points that show the temporary points are monitoring the same horizon. This demonstration must be submitted and sealed by a PG or a PE. If the demonstration is acceptable, EPD will require the monitoring plan be modified to incorporate the new compliance monitoring location, through a minor modification request. The minor modification request should include site maps showing both locations, and cross-sections demonstrating that the new monitoring point is monitoring the same interval as the existing approved location, The original monitoring location should simultaneously be removed from the monitoring system, and either abandoned or retrofitted as a gas vent.

REPORTING REQUIREMENTS

The SWM-19 form (Appendix B) is to be completed in its entirety and should not be modified prior to submittal to EPD. All supporting data must accompany the form. The form needs to be submitted to EPD within 14 days of the routine monitoring event, directly to the Solid Waste Management Program, located at 4244 International Parkway, Suite 104, Atlanta, Georgia, 30354. A copy of the report or cover letter needs to be provided to the facility's EPD District compliance officer.

SECTION 5: REMEDIAL MEASURES

If it is determined an exceedance is valid, the facility has 60 days to develop a methane remediation plan. The plan needs to be developed in accordance with guidance provided in EPA's MSW Landfill Criteria Technical Manual Remedial Measures Section 3.5 which can be found at http://www.epa.gov/epawaste/nonhaz/municipal/landfill/techman/index.htm in Subpart C or RCRA Subtitle D Training Manual Section 4.5 (included in Appendix C). Remedial measures commonly used at landfills include the installation of passive vent wells in and/or out of the waste limits, vent trenches, active gas extraction systems inside and/or outside the waste mass, the addition of acreage to facilities and addition of new monitoring points to allow gas to naturally dissipate before reaching the new property boundary.

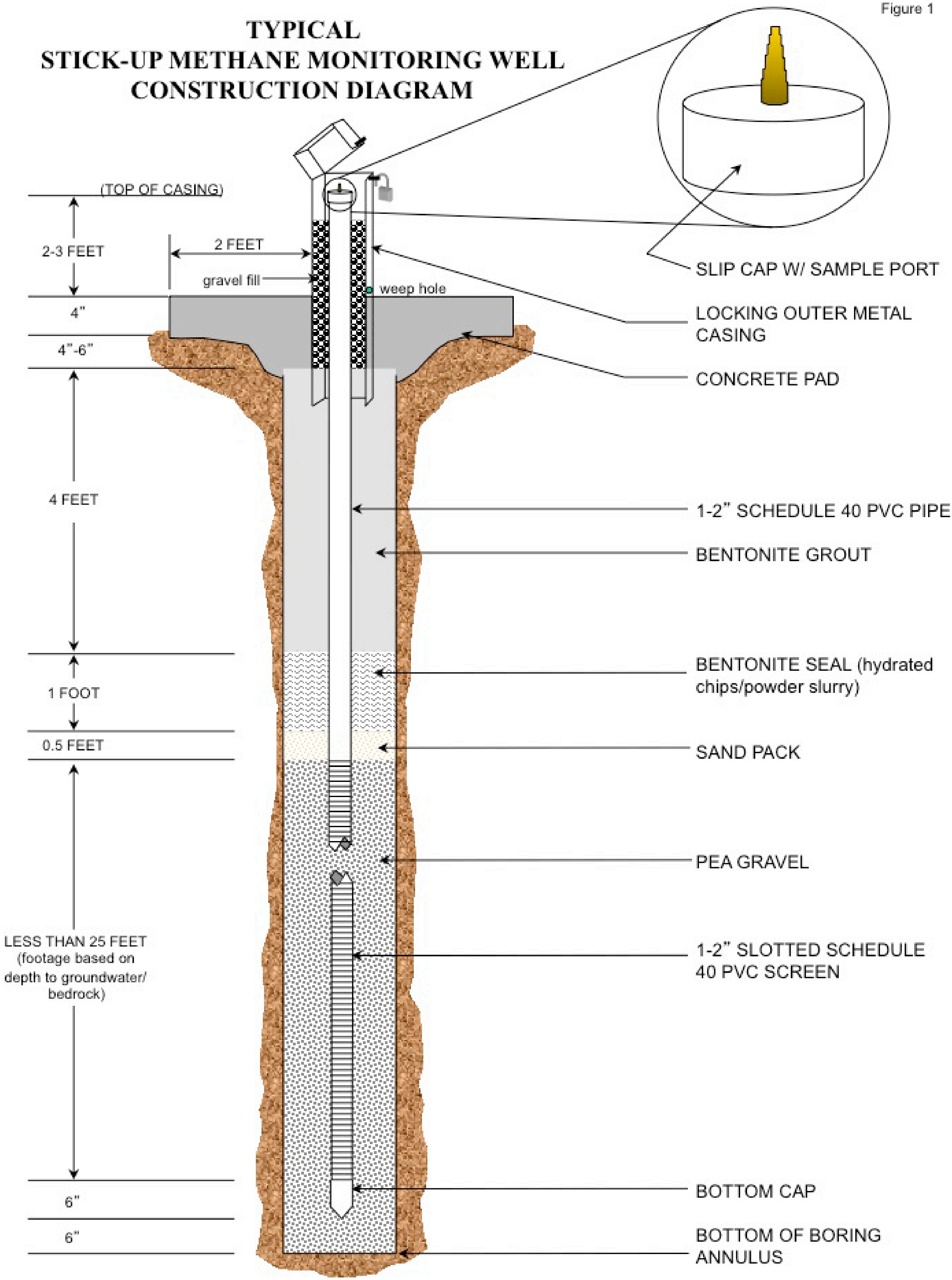
If it is determined that the remedial measure to be implemented includes the addition of acreage to the facility, a limited site assessment, developed in general accordance with Criteria for Performing Site Acceptability Studies for Solid Waste Landfills in Georgia (Circular 14) must be prepared for the added property, and the legal description of the permitted site modified to incorporate the additional acreage. Confirmation that the property is zoned appropriately for this usage must accompany the report.

As part of developing remedial measures, the nature and extent of the methane release must be determined. This may include the installation of additional temporary and permanent monitoring locations for delineation purposes. Only when the extent of the release is known can appropriate remedial measures be designed.

Regardless of the type of remedial measure to be implemented, the facility will need to submit a minor modification request to incorporate the remedy into the D&O Plans. Depending on the type and nature of the chosen remedy, EPD staff Geologists and Engineers may be involved in the review of the remediation plans. Some facilities may need to contact EPD Air Quality Branch to ensure their proposed remediation plans do not violate conditions of existing air quality permits. Odor Control Plans may be required if remedial measures include drilling in or excavating waste. Active gas extraction/control systems need to be developed in accordance with SWM-20 (Appendix D).

Figure 1

TYPICAL STICK-UP METHANE MONITORING WELL CONSTRUCTION DIAGRAM



TYPICAL FLUSH-MOUNT MEHTANE MONITORING WELL CONSTRUCTION DIAGRAM

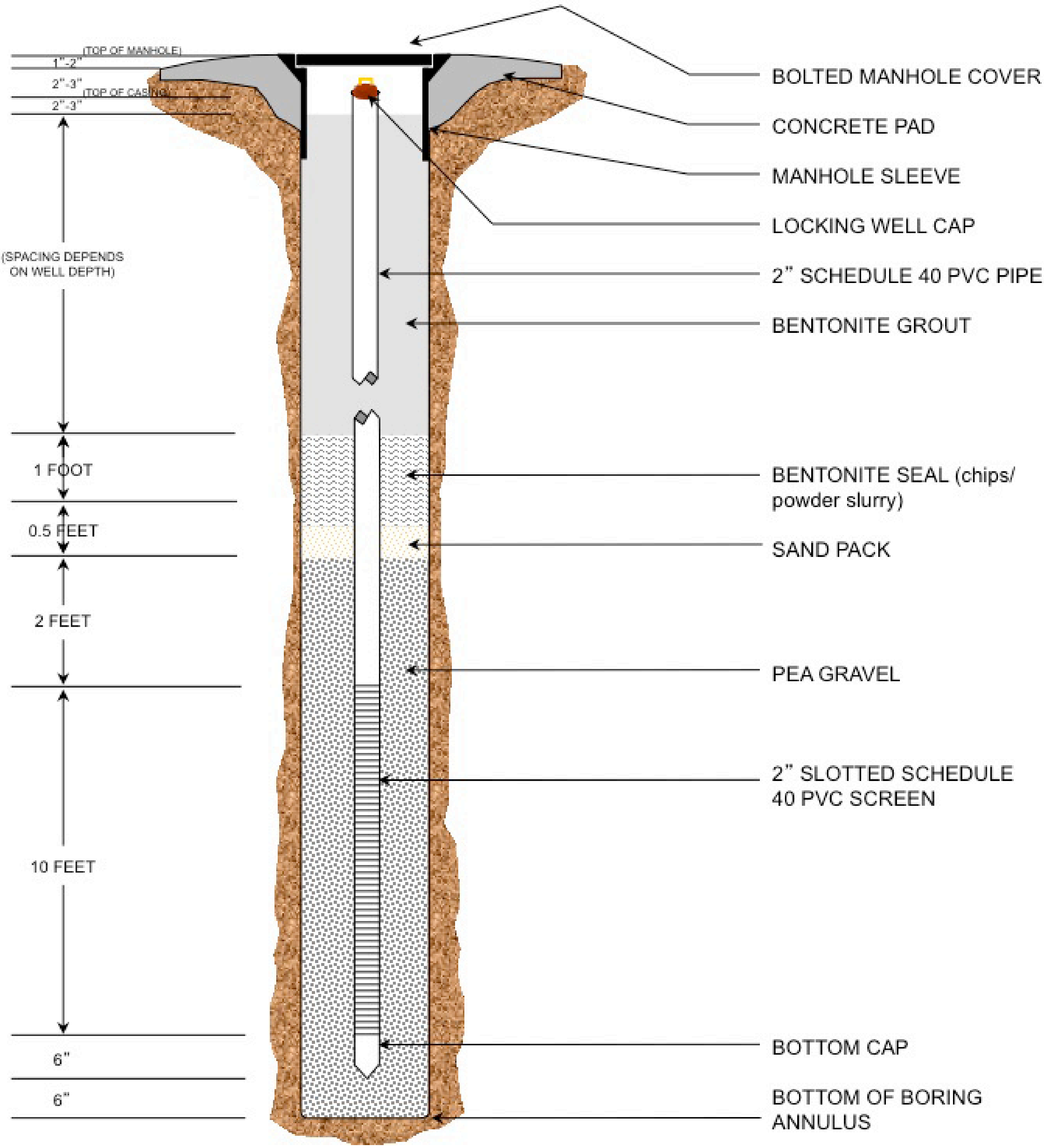


Table 1
As-Built Methane Monitoring Location Specifications

Monitoring Station Designation	Ground Surface Elevation	Depth to Water	Water Table Elevation	Screened Interval Elevations	Depth to Rock	Top of Rock Elevation
MM-1						
MM-2						
MM-3						
MM-4						
MM-5 (BHP)						
MM-6 (BHP)						

Methane Monitoring Plan Review Checklist

County ______________________
Site ______________________
Application/Permit Number ____________
Receipt Date ____________
Review Date ____________

		yes	no	n/a
1	Site Maps			
a.	Area map noting any offsite potential receptors within 1/2 mile			
b.	Topographic site map, scaled consistently with approved D&O Plans, depicting:			
	1 Facility property boundary			
	2 Waste unit boundary (Existing and Proposed)			
	3 All structures within 300 feet of the facility			
	4 Proposed methane monitoring locations			
	5 Monitoring proposed between site and adjacent structures			
	6 Current potentiometric surface map			
c.	Plan must be signed/sealed by PG/PE			
2	Supporting Data			
	Hydrogeologic assessment of site			
	Performed in accordance with Circular 14 if MSWL, C&D or Industrial, or			
	In accordance with Inert Guidance			
3	Plan Narrative			
a.	Justification for spacing/locations/depths of proposed wells/barhole punches			
b.	Well construction specifications to be included in plan:			
	1 Drilling Method			
	2 Drilling Fluid (if applicable)			
	3 Well/barhole punch locations surveyed to an accuracy of +/- .5 foot			
	4 Borehole diameter			
	5 Well casing diameter			
	6 Well depth to +/- .1 foot			
	7 Drilling logs			
	8 Lithologic logs with methodology for determining lithology specified (cuttings, cores, split spoons, etc.)			
	9 Casing and screen materials & joints specified			
	10 Slot size specified			
	11 Bottom cap			
	12 Filterpack material & size (normally pea gravel)			
	13 Sand layer above filter pack			
	14 Annular seal material (normally bentonite)			
	15 Annular seal placement method			
	16 Specification of material above annular seal			
	17 Placement method - if cement grout, should note installed with tremie pipe			
	18 Appropriate surface seal completion (4'x4' pad with locked protective casing)			
	19 Surveyed elevation of survey in pad (+/- .1 foot)			
	20 Detailed scaled drawings of each well (including surface seal and intervals of materials used)			
	21 Copy of drillers bond and verification on file with WWSAC			
	22 Certified, signed and sealed by PG/PE			

		yes	no	
c.	Appropriate abandonment protocols included in plans			

d. Appropriate sampling protocols specified for:

Item			
1 Wells			
2 Barhole punches			
3 Structures			
4 Vegetative survey			
5 Resample protocol			
6 Field calibration protocols			

e. Type of meter to be utilized

Item			
1 Specify meter to be used			
2 Provide user manual			

f. Reporting protocols

Item			
1 SWM-19 form will be submitted w/in 14 days of event to EPD			
2 Notification will be provided immediately to EPD if exceedance			
3 Within 7 days place in operating record			
4 Posting of no smoking signs			
5 Limiting access			
6 Notification of local authorities as needed			
7 Begin monthly methane monitoring and reporting			

g Remedial measures

Item			
1 Methane Remediation Plan developed			
2 Site Assessment if property added			
3 Revised Site Boundary if property added			
4 Easement agreements if necessary			
5 CQA Reports to be provided for any construction activities			
6 As-built documentation to be provided for remedial measures implemented			
7 Well installation reports for any additional wells installed			

Periodic Methane Monitoring Report

Appendix B

____
Quarter or Month / Year

Facility Name: ______________________ **Date(s) of Monitoring:** ______________________
Facility Permit #'s: ______________________ **Monitoring Conducted by:** ______________________
Permit #'s (cont): ______________________ **Equipment Field Calibrated by:** ______________________
County (Location): ______________________ **Date of Field Calibration:** ______________________
Monitoring Equipment: ______________________ **Manufacturer Calibration/Service Date:** __________

1. All reports must include a scaled and dated potentiometric surface map, (this applies only to those facilities required to perform groundwater monitoring) that shows ALL monitoring points, accompanied by a table listing the as-built depths and corresponding elevations of the bottoms of the methane monitoring wells and/or barhole punches. The potentiometric surface maps must be updated on an annual basis, signed & sealed by a qualified groundwater scientist. Those facilities that do not conduct groundwater monitoring should, at a minimum, include a site map that shows ALL monitoring locations.

2. All reports must specify whether each monitoring location is a structure, permanent well, barhole punch or vent (e.g. MM-1=scalehouse, MM-1=well, MM-1=BHP (barhole punch), MM-1=vent, or GWC-1=groundwater well).

3. Monitoring Results

a. Permanent Approved COMPLIANCE Monitoring Locations

Monitoring Point Identification	Monitoring Results		Monitoring Point Identification	Monitoring Results	
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________

a. Permanent Approved COMPLIANCE Monitoring Locations (continued)

Monitoring Point Identification	Monitoring Results		Monitoring Point Identification	Monitoring Results	
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________
________	% Methane By Volume:	________	________	% Methane By Volume:	________
	% Oxygen:	________		% Oxygen:	________
	Time Sampled:	________		Time Sampled:	________

b. Facility Structures (All on-site structures must be monitored, listed, and shown on map)

Facility Structure	Monitoring Results		Facility Structure	Monitoring Results	
________	% LEL:	____	________	% LEL:	____
	% Methane by Volume:	____		% Methane by Volume:	____
	% Oxygen:	____		% Oxygen:	____
	Time Sampled:	____		Time Sampled:	____
________	% LEL:	____	________	% LEL:	____
	% Methane by Volume:	____		% Methane by Volume:	____
	% Oxygen:	____		% Oxygen:	____
	Time Sampled:	____		Time Sampled:	____
________	% LEL:	____	________	% LEL:	____
	% Methane by Volume:	____		% Methane by Volume:	____
	% Oxygen:	____		% Oxygen:	____
	Time Sampled:	____		Time Sampled:	____

c. Miscellaneous Monitoring Locations (vents, trenches not part of compliance monitoring)

Monitoring Point Identification	Monitoring Results		Monitoring Point Identification	Monitoring Results	
____	% Methane By Volume:	____	____	% Methane By Volume:	____
	% Oxygen:	____		% Oxygen:	____
	Time Sampled:	____		Time Sampled:	____
____	% Methane By Volume:	____	____	% Methane By Volume:	____
	% Oxygen:	____		% Oxygen:	____
	Time Sampled:	____		Time Sampled:	____
____	% Methane By Volume:	____	____	% Methane By Volume:	____
	% Oxygen:	____		% Oxygen:	____
	Time Sampled:	____		Time Sampled:	____
____	% Methane By Volume:	____	____	% Methane By Volume:	____
	% Oxygen:	____		% Oxygen:	____
	Time Sampled:	____		Time Sampled:	____
____	% Methane By Volume:	____	____	% Methane By Volume:	____
	% Oxygen:	____		% Oxygen:	____
	Time Sampled:	____		Time Sampled:	____
____	% Methane By Volume:	____	____	% Methane By Volume:	____
	% Oxygen:	____		% Oxygen:	____
	Time Sampled:	____		Time Sampled:	____
____	% Methane By Volume:	____	____	% Methane By Volume:	____
	% Oxygen:	____		% Oxygen:	____
	Time Sampled:	____		Time Sampled:	____

d. **Adjacent Off-site Structures** (offsite structures at facilities with known release)

Off-site Structure	Monitoring Results		Off-site Structure	Monitoring Results	
______	% LEL:	______	______	% LEL:	______
	% Methane by Volume:	______		% Methane by Volume:	______
	% Oxygen:	______		% Oxygen:	______
	Time Sampled:	______		Time Sampled:	______
______	% LEL:	______	______	% LEL:	______
	% Methane by Volume:	______		% Methane by Volume:	______
	% Oxygen:	______		% Oxygen:	______
	Time Sampled:	______		Time Sampled:	______

4. Climatic/Physical Conditions at Site

Samples must be collected under normal/average conditions of temperature, pressure, and climate for the season. Barhole punch sampling should not be performed during or immediately after rain events, or when soils are saturated or frozen. **All sampling at compliance monitoring locations must be performed after 12:00 pm, and completed by 6:00 pm.** Barometric information can be obtained from many locations. (i.e. http://weather.noaa.gov)

a. Soil Conditions: ______

b. Weather Conditions: ______

c. Temperature: ______

d. Barometric Conditions: Rising ______ Falling ______ Steady ______ Reading ______

e. Relative Humidity 10%-90%? Yes ______ No ______ Range: ______

f. Condition/Access: Sampling points are properly identified, secured and maintained?

Yes ______ No ______

If no please list deficiencies observed:

______

______

______

g. If stressed vegetation due to the presence of methane gas is noted, describe the extent and location in the space provided below.

______

______

5. Description of Sampling Techniques: Provide a clear and concise description for each type of sampling (well, barhole punch, structure, etc.) performed during the monitoring event. Wells are **NOT** to be vented, peak readings should be reported. Any exceptions should be noted here.

______

______

______

______

______

6. Additional Comments

______

______

______

______

CERTIFICATION

I CERTIFY that all required information on this form is complete and accurate, and

I further CERTIFY that methane sampling was conducted by myself or my authorized representative in accordance with all applicable rules and current EPD guidance. Concentrations of methane detected during this sampling/monitoring event __**do** / __ **do not** exceed 25 percent of the lower explosive limit (LEL) for methane in facility structures (excluding the gas recovery system components) and gas concentrations __ **do** / __ **do not** exceed the LEL for methane at the approved compliance monitoring locations.

(IF THIS STATEMENT IS NOT SIGNED OR THE FORM IS ALTERED THE DIVISION WILL NOT ACCEPT THE RESULTS FROM THE SUBJECT FACILITY)

(Signature) (Title) (Date)

(Typed Name, Address, and Telephone Number)

4.5 PASSIVE AND ACTIVE GAS MANAGEMENT SYSTEMS

A variety of technologies are available for controlling landfill gas accumulation and migration. Landfill gas management systems are designed for two purposes: extracting gas from the landfill and controlling gas migration. Two types of systems, passive and active, are used depending upon the gas management purpose and rate of gas accumulation and migration.

The type of gas management system required is dependent upon the gas management objectives (gas removal or migration control) and a number of site factors including:

- Landfill size and age;
- Facility design (lined, capped or covered);
- Type of waste (organic content of waste);
- Waste volume and thickness; and
- Local conditions (geology, site features, adjacent land use and demographics).

Care must be taken in designing gas control systems, especially passive systems, to prevent them from providing a pathway for unwanted infiltration of surface water. Improper design could allow the vent to intercept surface runoff and pipe additional infiltration into the landfill and leachate collection system.

4.5.1 Passive Gas Management Systems

Passive gas management systems rely upon the natural forces of convection and diffusion to control landfill gas migration. Passive systems are designed to create preferential pathways for gas migration, collection and venting at controlled discharge points. Examples of passive gas management systems include the following:

- Open ditches
- Vent trenches
- Impermeable barriers
- Vent layers and vertical vents (wells)
- Substructure vents

4.5.1.1 *Open Ditches*

Open ditches can be used to provide for venting of laterally migrating gases at the perimeter of the landfill or between the landfill and the property boundary. The use of open ditches within the landfill disposal area is difficult considering the new requirements for daily cover and leachate management. The use of open ditches outside the disposal area may still be practical for controlling lateral gas migration. The effectiveness of these simple installations is also dependent upon the depth of the landfill, depth of the ditch and depth, thickness and permeability of the migration pathway.

4.5.1.2 *Vent Trenches*

Passive vent trenches are designed and constructed either to prevent lateral migration of landfill gas or to collect the gas from within the landfill.

Gravel-filled vent trenches are better than open ditches at passively venting laterally migrating landfill gas. Open vent trenches used for lateral migration control are often constructed with impenetrable barriers on the outer side of the trench, away from the methane source, to prevent migration of the landfill gas to the surrounding area.

Like open ditches, vent trenches present problems when installed within the landfill. Vent layers (discussed below) are preferable because they are designed with impenetrable barriers above the permeable layer to prevent infiltration.

Vent trenches installed outside the landfill waste disposal area often extend from the surface down to a low hydraulic conductivity soil layer or other barrier such as the water table or a Flexible Membrane Liner. These systems may be installed as deep as the bottom of the landfill if outside the waste disposal area. Cost, related to depth of installation, becomes a limiting factor in the effective application of this passive system.

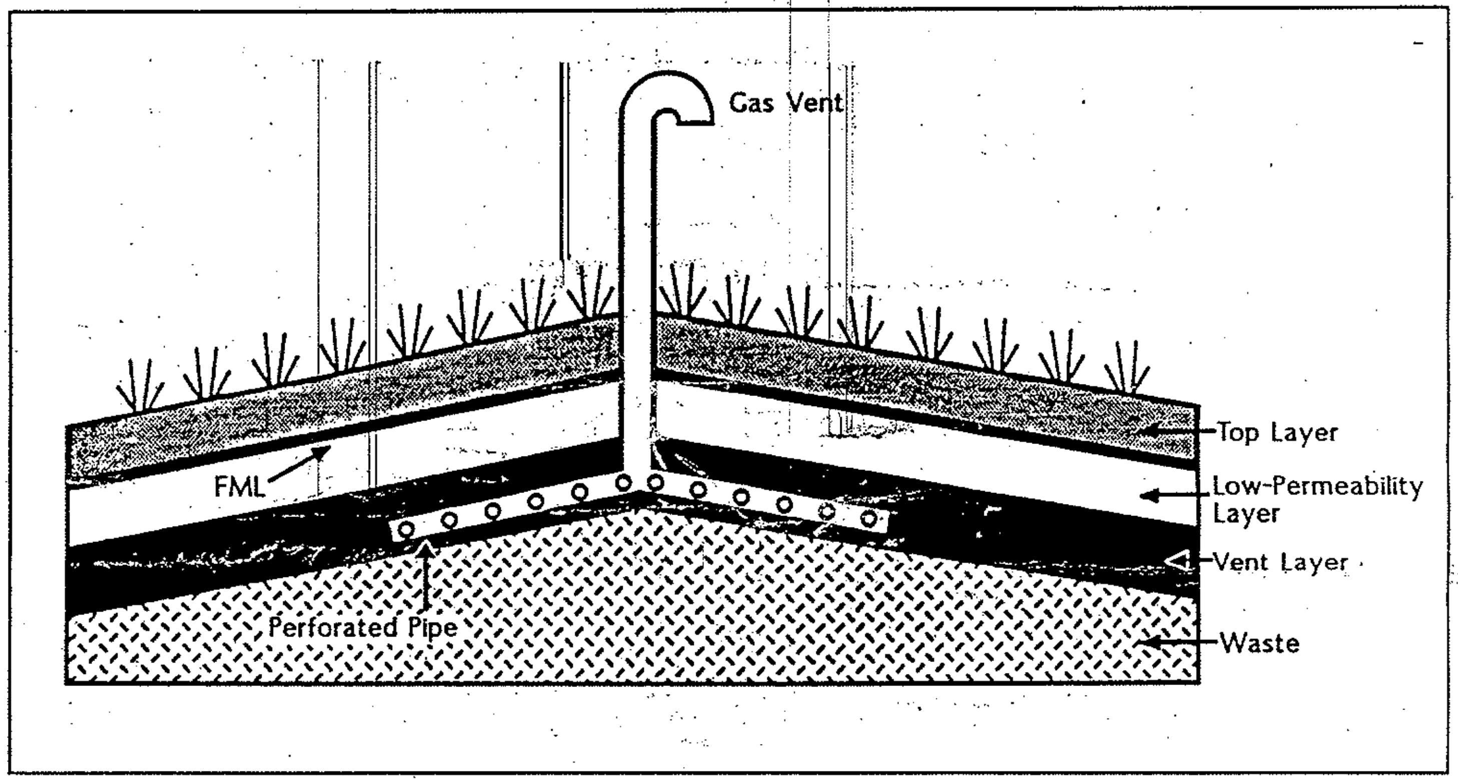
4.5.1.3 *Impermeable Barriers*

Impermeable barriers such as slurry walls can be used to create a barrier to gas migration. Other materials which also create impermeable barriers and could be used to prevent lateral gas migration are Flexible Membrane Liners or water infiltration barriers (i.e., constructed wetlands or stormwater retention/infiltration ponds).

4.5.1.4 *Vent Layers and Vertical Vents (Wells)*

Vent layers and vertical vents are gas management system components which are commonly installed within the landfill for either passive or active gas removal purposes (figures 4-5 and 4-6). Passive gas management systems may incorporate vent layers constructed of highly permeable material (i.e., gravel), composite covers and verti-

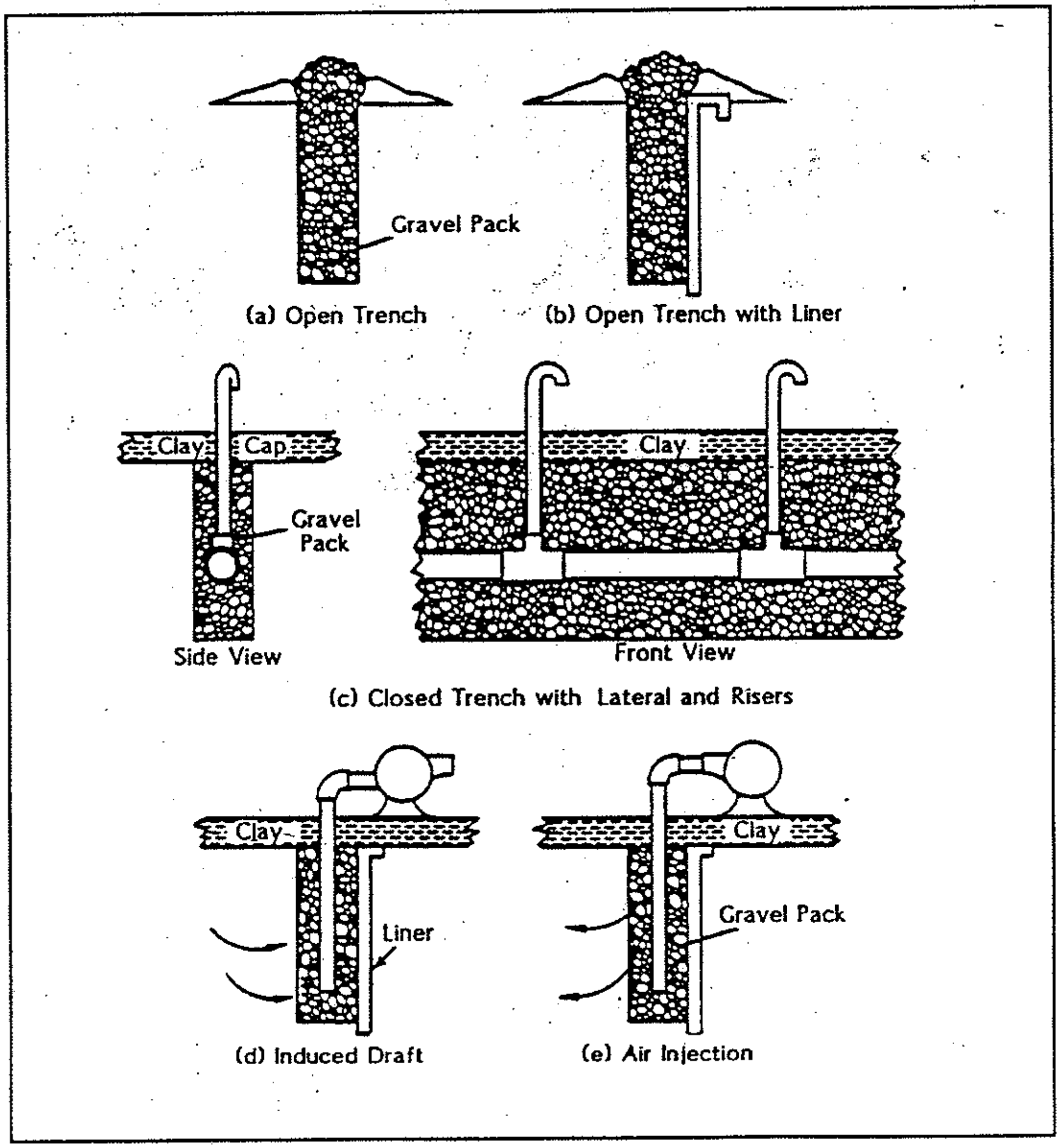
Typical Passive Vent Layer Gas Management System



(Source: EPA, 1993)

Figure 4-5
4-20

Vent Layers and Vertical Vents (Wells)



(Source: EPA, 1982)

Figure 4-6
4-21

cal vents to release gas from the landfill. The composite cover prevents uncontrolled vertical migration, while the vent layer intercepts vertically migrating gas and directs it to the surface via vent pipe(s) that are installed along the high point of the waste cell. The vertical vents (wells) may extend deeper into the landfill to provide a vertical migration pathway for gas to enter the vent layer from deeper layers within the landfill. These systems induce landfill gas to migrate vertically rather than laterally.

4.5.1.5 *Substructure Vents*

Substructure vent systems can be installed to prevent gases from accumulating beneath structures. Passive substructure vent systems require placement of a permeable system (piping and gravel layer) beneath the foundation slab of the structure to provide a preferential pathway for gas venting, thereby preventing migration of landfill gas into the structure. The gas must be vented away from the structure to prevent accumulation in other traps (i.e., overhangs, utility closets or the structure itself).

4.5.1.6 *Active Gas Management Systems*

Active gas management (extraction) systems use mechanical components to control and collect landfill gas. Active systems create positive or negative pressure gradients to drive the landfill gas to the point of extraction. Examples of active gas management systems include the following:

- Extraction systems (trenches and/or wells)
- Injection barriers
- Substructure extraction

In order to be effective, active gas extraction systems must be designed to draw gas from throughout the landfill and not preferentially from air infiltration conduits. Factors which must be considered in designing active gas extraction systems include the following:

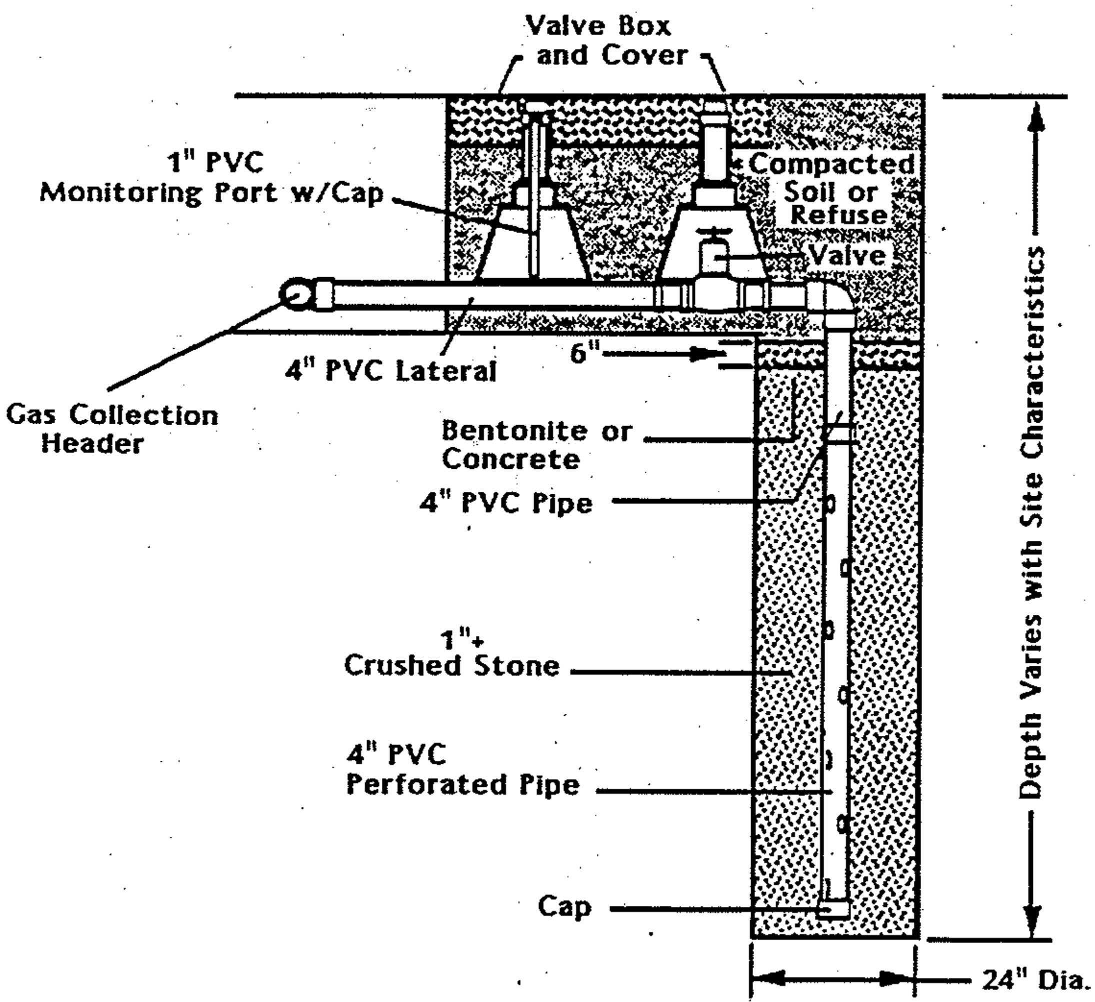
- Facility design (lined and unlined cells);
- Disposal practices (waste disposal in discrete cells); and:
- Thickness of the landfill (highest methane generation potential is in the center of the landfill where waste placement is thicker).

4.5.1.7 *Extraction Systems (Trenches and/or Wells)*

Active gas extraction systems may include a series of trenches and/or wells with collection headers for extracting gases from deeper layers within the landfill. Trenches are generally employed as perimeter gas extraction systems or at shallow depths within the landfill while wells are more practical as primary extraction systems in the thickest portions of the landfill. The well casings and/or piping installed within the trenches are connected to extraction blowers or pumps. Typical active gas extraction wells and trenches are shown in figures 4-7 and 4-8. Gas extraction wells do not have to extend to the bottom of the landfill since suction applied to the system is able to draw gas from a sizeable area beyond the gravel pack which surrounds the well screen.

Impermeable barriers in the cover and landfill perimeter walls increase the efficiency of active gas extraction systems since they restrict inflow of air that would dissipate the suction. These barriers also reduce the number of wells and/or trenches

Typical Gas Extraction Well

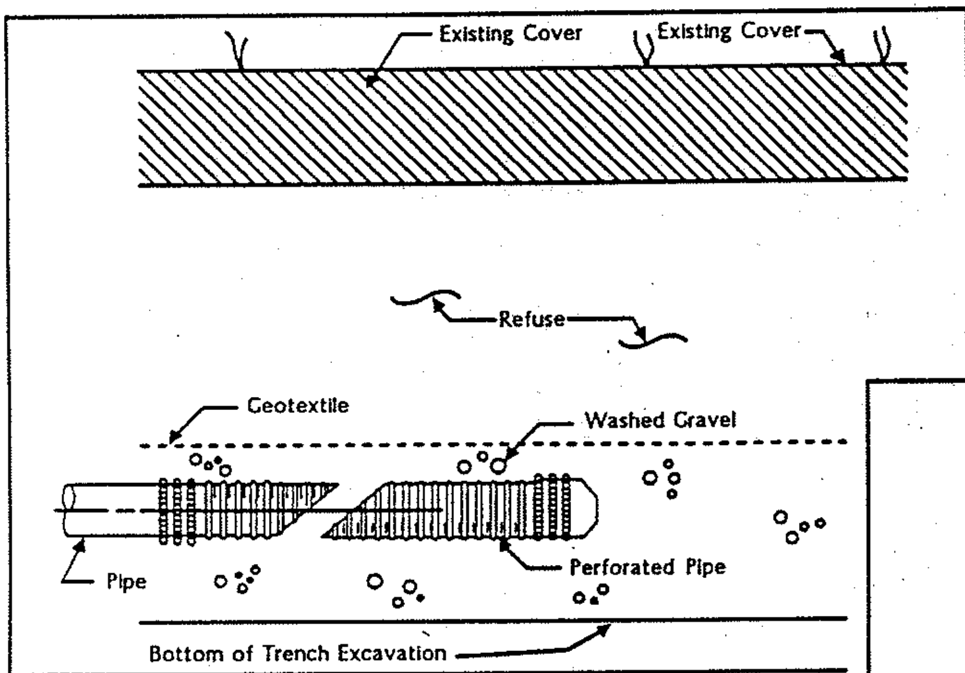


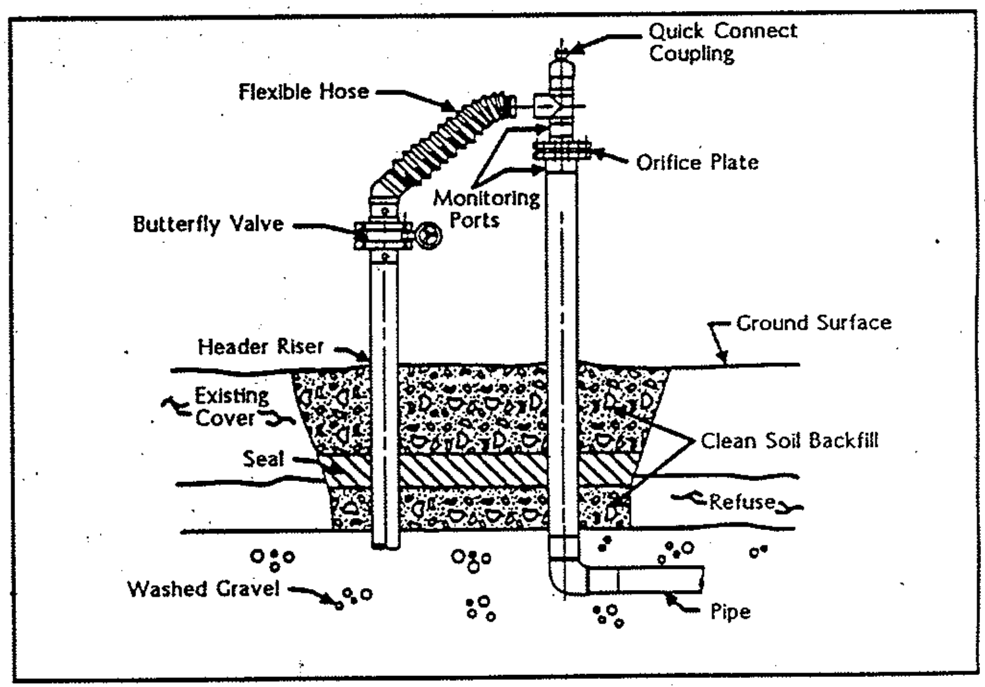
(Source: SCS, 1980)

Figure 4-7
4-23

Typical Gas Extraction

Trench and Header





(Source: SWANA, 1991)

Figure 4-8
4-24

needed and increase the heating value of the gas collected.

Gas extraction systems should be designed so that portions of the system can be disconnected or shut off as necessary to adjust for increased infiltration of surface air due to active disposal or insufficient or permeable cover. If properly designed and operated, methane gas extraction systems can be used for energy production or as the primary fuel for a flare.

4.5.1.8
Injection Barriers

Injection of air or water can be used as an active mechanism to restrict lateral migration of landfill gases. Air injection systems are installed in a perpendicular direction to the gas migration pathway. Air is injected through a header system to create a subsurface pressure gradient which restricts or reverses the direction of gas migration. Water injection barriers are not commonly used for gas migration control; however, infiltration galleries can be used to impede gas migration at shallow depths.

4.5.1.9
Substructure Extraction

Active substructure extraction systems are similar to passive substructure venting systems, but are more effective in providing for controlled removal of gases. Active substructure extraction systems can also be designed for short-term remediation purposes where the system is installed above the slab (in basements or crawl spaces).

4.6 GAS MANAGEMENT SYSTEM OPERATION AND MONITORING

Gas management systems are constructed and operated both within the landfill (primary wellfields) and at the perimeter of the landfill (either inside or outside of the landfill waste disposal area). Both types of systems must be monitored for optimal performance.

4.6.1 Primary Gas Extraction Wellfields

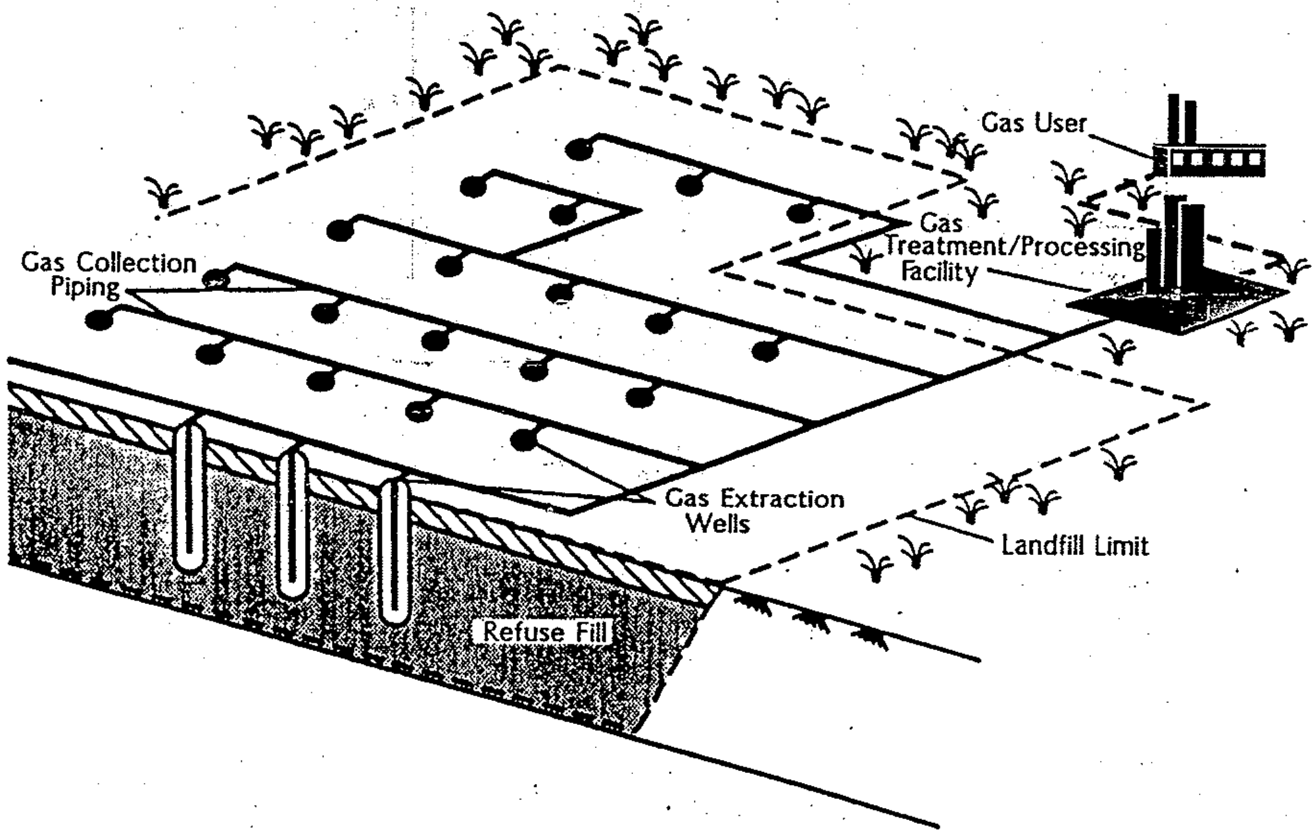
Primary (interior) gas extraction wellfields are the most efficient and often the largest component of a comprehensive gas extraction system. Their function is to collect most of the landfill gas at the point of generation (within the landfill.) Extraction wellfield systems normally include a number of wells spaced evenly over the entire landfill (Figure 4-9). Spacing and design of the extraction well field is dependent upon landfill design (lined or unlined), waste voids and layering and landfill cell configuration. Separate extraction well systems may be necessary to segregate gas extraction from high and low methane generation areas.

Improper operation of gas extraction well systems can result in excess emissions of landfill gas to the atmosphere, gas migration and overpulling of the wellfield which can disrupt anaerobic decomposition or cause subsurface fires.

The frequency of gas extraction wellfield monitoring will vary depending upon field requirements and conditions. Normal monitoring frequency for a complete field monitoring program will vary from once a week to once a month. Wellfield monitoring should not normally be extended beyond once a month, especially on active landfills. Too many things can happen which can result in inefficient or detrimental operation of the gas extraction system.

The importance of regular, timely and thorough monitoring cannot be overemphasized. Improper operation of the primary gas extraction wellfield system puts additional requirements on perimeter gas migration control systems.

Typical Primary Gas Extraction Wellfield System



(Source: EMCON, 1981)

Figure 4-9
4-25

4.6.2 Perimeter Gas Migration Control Systems

Perimeter gas migration control systems extract poor quality landfill gas that is often high in oxygen due to air intrusion at the interface of the landfill and the native soil. Operating objectives for the perimeter system are different than for the primary gas extraction wellfield system. The perimeter system provides a final opportunity to capture gas before it escapes from the landfill and migrates to adjacent properties or structures.

Perimeter gas migration control systems may be installed within the landfill near the perimeter or in native soil adjoining the landfill depending upon the design objectives for controlling gas migration. Gas migration pathways can change drastically at the perimeter, making gas quality and control difficult. For this reason, perimeter gas wells or trenches are often tied into a separate extraction system.

Perimeter gas management systems generally require more frequent monitoring on a weekly or even daily basis depending upon the methane concentration of the migrating gas. The danger of subsurface fires, caused by air intrusion, is more significant where perimeter gas management systems are operated at high extraction rates.

Landfill gas migration is usually decreased if the primary gas management system pulls gas toward the center of the landfill instead of allowing the landfill gas to be pulled toward the perimeter system. The perimeter migration system, then, only has to extract locally generated gas rather than gas already migrating towards the perimeter of the landfill.

References

1. U.S. Environmental Protection Agency, Design and Construction of RCRA/CERCLA Final Covers, EPA/625/4-91/025 (Cincinnati, OH: GPO, 1991).
2. U.S. Environmental Protection Agency, Design, Operation and Closure of Municipal Solid Waste Landfills, EPA/600/K-92/002 (Washington, DC: GPO, 1992).
3. U.S. Environmental Protection Agency, Requirements for Hazardous Waste Landfill Design, Construction, and Closure, EPA/625/4-89/022 (Cincinnati, OH: GPO, 1989).
4. Landfill Control Technologies, Technical Tips, Bulletin #102 (1992)
5. N. Irving Sax, and Richard J. Lewis, Dangerous Properties of Industrial Materials, Seventh Edition (New York, NY: Van Nostrand Reinhold, 1989).
6. U.S. Department of Transportation, U.S. Coast Guard, Chemical Hazards Response Information System (CHRIS) Manual, M16465.11a (Washington, DC: 1985).
7. Solid Waste Association of North America, Landfill Gas Division: A Compilation of Landfill Gas Field Practices and Procedures (March 1987).
8. Commonwealth of Pennsylvania, Department of Environmental Resources Bureau of Waste Management, Guidance Manual for Landfill Gas Management (September 1986).
9. U.S. Environmental Protection Agency, Virginia Landfill Training, EPA Contract No. 68-W0-0025, WA No. 253 (1993).
10. Emcon Associates, Methane Generation and Recovery from Landfills, (Ann Arbor, MI: Ann Arbor Science Publishers, Inc., 1980).
11. G. H. Farquhar, and F.A. Rovers, Gas Production During Refuse Decomposition, Water, Air and Soil Pollution (1973).
12. U.S. Environmental Protection Agency, Handbook for Remedial Action at Waste Disposal Sites, EPA/625/6-82/006 (Cincinnati, OH: GPO, 1982).

Department of Natural Resources
Environmental Protection Division
Land Protection Division
Solid Waste Management Program
4244 International Parkway, Suite 104
Atlanta, Georgia 30354
(404) 362-2692

METHANE GAS RECOVERY/VENTING SYSTEMS DESIGN AND OPERATIONAL PLAN

Supplemental Data for Solid Waste Handling Permit

The Design and Operational Plan should be developed only after the letter of site acceptability from EPD has been received. It is desirable to have design review meetings with the applicant, consultant and EPD during plan development. The preliminary design review should cover conceptual design layout using engineering sketches. EPD will also make an onsite investigation as part of the design review procedure. The final design review will include detail review of the final design. The following format is to be followed and specifications addressed in development of the plan.

General

D&O Plan sheet dimensions must be 24" x 36".

All sheets in the plan are to be the same size using a title block.

The plan is to be complete, in and of itself. Auxiliary manuals will not be accepted.

Format

Title Sheet

- Location map
  - Minimum 5-mile radius from site
  - DOT County Map or equivalent; Map shall be updated through local reconnaissance. Show north arrow.
  - Direction of stream flow
- Official gas recovery/venting system name
- Official disposal site name
- Table of contents
- Responsible official: Title, address and telephone number
- Property owner: Name, address and telephone number
- Consultant: Name, address and telephone number

Site Design Sheets

Scale: 1 inch = 100 feet. Indicate north arrow.
Match lines: On a site specific basis, the use of match lines may be necessary. The match lines must break at phase boundaries so that a mosaic of 2 or more sheets need not be constructed for a phase.
Property lines: Show bearings and lengths.
Disposal area boundaries.
Topography: Must extend at least 50 feet beyond property lines
Existing topography: identify all existing physical/land features and previously filled areas
Final topography
Contour interval: 2 feet unless another interval is approved by EPD
Survey bench mark identification and elevation

Gas Recovery/Venting System

Plan showing collection wells, transmission pipeline, condensate disposal wells/storage, location of preliminary test wells, conduit dimensions, joint and valve locations, etc.
Site profile(s), if necessary
Flow chart to show process elements (schematic)
Gas flow rates
Typical detail sections;
Joints, wells, couplers, moisture traps, etc.

Design and Operational Plan Information Sheet – Narrative

1. Recovery/Venting well data
   a. Gas constituency analysis

Methane	Percent by Volume
Carbon Dioxide	Percent by Volume
Oxygen	Percent by Volume
Nitrogen	Percent by Volume
Propane and Heavier Hydrocarbons	Percent by Volume
Total Sulphur	PPM
Reduced Sulphur (as H_2S)	PPM
Total Halogen	PPM
Vinyl Chloride Monomer	PPM
Chlorinated Organics	PPM
Moisture Content	Percent by Volume

   b. Well data

Depth of waste	Ft.
Depth to water table	Ft.
Depth of wells	Ft.

2. Survey control during construction and installation
3. Emergency procedures and safety and security
4. Power source
5. Startup date for recovery/venting systems
6. Gas user(s) (name and address) Easements
7. Site closure (date and anticipated effect on Gas Recovery System)
8. Description of gas clean up process
9. Process residuals and emissions (list with concentrations)
10. Construction schedule
11. Manpower requirements
12. Gas Recovery operation termination
    a. Estimated life expectancy
    b. Procedures for operation termination
13. Equipment specifications
14. Condensate handling and disposal
15. Copy of agreement between property owner, disposal site operator, and gas recovery operator submitted to EPD on ______________.
    (date)
16. Other EPD Permits
    a. Air Quality
    b. Water Quality
17. Public Service Commission approval (for 2 more users)