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Control of Odorous Gas at Massachusetts Landfills

In Support of 310 CMR 19.000, Solid Waste Management Regulations

Massachusetts Department of Environmental Protection
Bureau of Waste Prevention
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Date

A handwritten signature in black ink that reads "James C. Colman".

James C. Colman
Assistant Commissioner
BWP



This document is intended to guide parties in complying with the Solid Waste Regulations at 310 CMR 19.000 and the Air Quality Regulations at 310 CMR 7.00.

This Policy does not create any substantive or procedural rights, and is not enforceable by any party in any administrative proceeding with the Commonwealth. This Policy provides recommendations and guidance on approaches MassDEP considers acceptable for meeting the performance standards set forth in the Solid Waste Management Facility Regulations, 310 CMR 19.000, and the Air Quality Regulations, 310 CMR 7.00, and discussed in this document. Other options for demonstrating compliance with the regulations may be acceptable. The regulatory citations in this document should not be relied upon as a complete list of the applicable regulatory requirements.

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I. Introduction

A large number of odor complaints have been made over the past several years by people living or working near landfills, in particular, near landfills that have been using construction and demolition (C&D) residuals and fines as daily cover and/or grading and shaping material. However, odor problems can occur at any landfill. The Massachusetts Department of Environmental Protection (MassDEP) is concerned about emissions of hydrogen sulfide (H₂S) as well as other landfill gasses and is focusing on prevention, identification, quantification and control of H₂S emissions as a means of addressing both odors and H₂S. Because other landfill gasses usually are found along with H₂S, MassDEP anticipates that efforts to control H₂S emissions will have the added benefit of controlling emissions of other landfill gasses as well. This document establishes which landfills must submit a Hydrogen Sulfide and Odorous Landfill Gas Response Plan (the "Plan"), provides guidance for the preparation of the Plan, and provides guidance on recommended management practices to prevent or minimize generation of odors at landfills, in particular, at landfills where the use of C&D residuals and/or fines as daily cover and/or grading and shaping material is proposed. This document is not intended to address landfill soil gas migration and safety (i.e. explosion) concerns associated with methane and related corrective actions.

Hydrogen sulfide is one of the most common compounds responsible for landfill odors and can have an extremely low odor threshold (the lowest reported value is 0.5 ppb in Ruth, 1986 cited in ATSDR, 2004¹), but levels at which odors become apparent may vary significantly.

Hydrogen sulfide and other landfill gas emissions can be minimized and controlled by instituting proper operation and maintenance at a landfill. Where odor problems do occur, the decision about whether hydrogen sulfide and other malodorous landfill gas emissions require corrective actions depends on whether the odors are of sufficient frequency, intensity, duration and offensiveness as well as other factors such as adjacent land uses, the presence of an exposed population and the location of the facility.

Where a problem has the potential to occur, MassDEP is requiring a Plan to be developed, pursuant to 310 CMR 19.000, that the facility will use to address odors, should they occur. MassDEP has established two tracks for taking such actions at facilities. The first is triggered by the presence of nuisance odors at or in the vicinity of a facility. The second is triggered by the presence of hydrogen sulfide at a concentration exceeding the action level at a facility compliance point, usually at or near the property line, regardless of whether odors have impacted anyone near the facility. These two tracks are the primary tools for making decisions on when landfill gas emissions are at concentrations that would require additional assessment and corrective actions.

This document is intended to assist regulators and the regulated community in making decisions that are both consistent from landfill to landfill and protective of public health, safety and the environment. Additionally, this document includes Recommended Management Practices (“RMPs”) for landfill operations that will reduce the potential for generation of landfill gas odors and the production of hydrogen sulfide gas.

The regulatory citations provided throughout this document are not meant to be a complete list of all the regulatory requirements concerning landfill gas emissions, air quality requirements and risk characterization at Massachusetts’s landfills. In addition, there is uncertainty with regard to whether the RMPs will reduce or eliminate landfill gas odors and H₂S emissions to acceptable levels due to site-specific considerations. Therefore, the list of actions to be taken by landfill operators in Tables 1 and 2 and the RMPs suggested by MassDEP in Table 3 should be considered minimum management practices to be instituted should there be a problem at a landfill. If these measures are not successful in reducing H₂S emissions and eliminating odor problems MassDEP may require other measures to be taken until the H₂S emissions and/or odor problems are resolved in accordance with 310 CMR 19.117, 19.130, 7.01 and 7.09.

II. Regulatory Background

The general landfill design standards and operational standards related to air quality are established within the Solid Waste Management Regulations at 310 CMR 19.117 (Air Quality Protection Systems) and 310 CMR 19.130 (Operation and Maintenance Requirements).

¹ Ruth, JH. 1986. Odor thresholds and irritation levels of several chemical substances – A review. Am Ind Hyg Assoc J 47:42-51. Cited in Agency for Toxic Substances and Disease Registry. 2004. Draft Toxicological Profile for Hydrogen Sulfide. Atlanta, GA.

MassDEP's regulations at 310 CMR 19.117 state, in part, that owners, operators and permittees of solid waste facilities have a duty to:

control the concentration levels of explosive and malodorous gases and other air pollutants as necessary in order to maintain air quality and to prevent the occurrence of nuisance conditions or public health or safety problems.

MassDEP's regulations at 310 CMR 19.130(16) Vector, Dust and Odor Control, state in part, that:

The operator shall prevent vectors, dust, odors and other nuisance conditions from developing at the landfill and any other areas related to the general facility operations.

The general air quality standards related to landfills are set forth in 310 CMR 7.00. MassDEP's Air Quality regulations at 310 CMR 7.00 define Air Pollution as:

the presence in the ambient air space of one or more air contaminants or combination thereof in such concentrations and of such duration as to:

- a) cause a nuisance;*
- b) be injurious, or be on the basis of current information, potentially injurious to human or animal life, to vegetation or to property; or*
- c) unreasonably interfere with the comfortable enjoyment of life and property or the conduct of business.*

The Air Quality regulations at 310 CMR 7.01(1) state:

No person owning, leasing, or controlling the operation of any air contamination source shall willfully, negligently, or through failure to provide necessary equipment or to take necessary precautions, permit any emission from said air contamination source or sources of such quantities of air contaminants which will cause, by themselves or in conjunction with other air contaminants, a condition of air pollution.

The Air Quality regulations at 310 CMR 7.02(1)(b) state, in part, that:

A plan approval is required prior to any construction, substantial reconstruction, alteration, or subsequent operation of a facility that may emit contaminants to the ambient air.

The Air Quality regulations at 310 CMR 7.09(1) state, in part, that:

No person having control of any dust or odor generating operations such as, but not limited to...dump operations...shall permit emissions therefrom which cause or contribute to a condition of air pollution.

This document provides guidance for meeting the general requirements set forth in the Solid Waste Management Regulations at Massachusetts landfills to protect public health, safety and the environment. Persons using this Policy should be aware that there may be other acceptable alternatives to specific actions required by this guidance for achieving compliance with the regulations.

III. Applicability

The following landfills are subject to this policy and must prepare a Hydrogen Sulfide and Odorous Landfill Gas Response Plan that meets the requirements of Section VII, Hydrogen Sulfide and Odorous Landfill Gas Response Plan:

- All landfills currently accepting solid waste that have historically or are currently generating landfill gas that is causing nuisance odors off-site;
- All unlined landfill closure projects that accept construction and demolition debris fines and/or residuals for closure in accordance with the "*Revised Guidelines for Determining Closure Activities at Inactive Unlined Landfill Sites*", revised July 2001; and
- Operating landfills that accept C&D residuals and/or fines for use as daily cover or disposal.

The policy and the requirement for developing a Plan do not apply to:

- Landfills that accept only ash, soils or other materials that do not have the potential to generate landfill gases in sufficient quantity as to cause nuisance odors; and
- Existing landfills that currently and historically have not had odor problems unless they are accepting C&D residuals and/or fines.

If a landfill that has not been required to develop a Plan develops an odor problem, MassDEP expects the landfill to self-implement the procedures in this guidance to resolve the odor issue. MassDEP reserves the right to require that the landfill owner/operator of any existing landfill that develops an odor nuisance problem comply with this policy and prepare a Plan. MassDEP may require the installation of hydrogen sulfide monitoring devices and gas collection and treatment systems during operations as necessary to maintain the environment free from objectionable nuisance conditions, potential dangers or threats to public health, safety or the environment resulting from emissions of landfill gases.

Landfills required to submit a Plan, or to modify an existing plan, to comply with this policy shall use BWP SW 22, Minor Permit Modification Application.

IV. Permitting Considerations

The most important consideration in preventing the generation of odors is to properly design and operate a landfill to minimize the potential for generation of odors and H₂S. Landfill gas collection and control systems need to be properly designed and operated so that H₂S and other odorous gasses are adequately controlled and secondary problems are not created, such as overloading a landfill flare with H₂S, which causes emissions of SO₂ from the flare to exceed permitted levels.

This document provides a number of Recommended Management Practices (RMPs) in Table 3 that landfill owners/operators should include in the operation of their facility, particularly in applications where C&D residuals and fines are to be used for daily cover or as grading and

shaping material in the closure of a landfill. Where landfills will use C&D residuals and/or fines, MassDEP will require applicants to provide the following as part of their permit application:

- designs for adequate gas collection and treatment systems, including pre-treatment systems to reduce H₂S
- adequate monitoring and maintenance of gas collection and treatment systems;
- a financial assurance mechanism (refer to 310 CMR 19.051: Financial Assurance Requirements) that includes monitoring and maintenance of gas collection and treatment systems through closure and post-closure and to address contingencies for remedial activities.

V. Action Level for Odorous Landfill Gas Emissions

This Policy establishes an Odor Action Level as the primary tool for making decisions about when landfill gas emissions are serious enough to require verification, assessment and possibly monitoring and/or corrective actions. Please note, a landfill may be required to take actions to address a condition of air pollution pursuant to 310 CMR 7.01 or 7.09(1) even where action levels are not exceeded.

The Odor Action Level established in this policy is based on the detection of odors from emissions of any landfill gasses and the presence of odors at nuisance levels offsite (indicated by odor complaints from the public and/or local Board of Health, landfill personnel or MassDEP observation). Table 1 lists the Odor Action Level along with information on what constitutes an exceedance of the Action Level and possible subsequent response actions.

Detection of odors offsite should trigger an immediate investigation by landfill owners/operators to verify that an odor problem exists, determine the source and cause of the odors and take steps necessary to abate the odorous gas emissions, regardless of whether the facility has developed a Plan.

Each owner/operator at an applicable landfill will be required to have a site-specific Hydrogen Sulfide and Odorous Landfill Gas Response Plan (see Section VII.) that is to be followed when verifying, assessing and implementing response actions for an odor problem. This assessment and/or monitoring is necessary to determine the extent and severity of the emissions of landfill gas and ensure that the public is not exposed to concentrations that may cause a nuisance condition or pose a potential risk to public health and/or safety. The owner/operator of a landfill that does not have a Plan, but at which an odor problem develops, should investigate the odor problem as outlined in Actions 1-3 of Table 1 and may be required to submit a Plan to MassDEP for review.

VI. Action Levels for Hydrogen Sulfide Emissions

This policy establishes, in addition to the Odor Action Level, two numerical action levels based upon monitoring of hydrogen sulfide gas. MassDEP established the Hydrogen Sulfide Action Level in addition to the Odor Action Level to abate hydrogen sulfide emissions before they cause off-site nuisance conditions or result in harm to public health. The H₂S Action Levels will therefore generally only come into play when gas monitoring has been triggered by the Landfill's

approved Plan or MassDEP has required gas monitoring to be done at a particular landfill as one of the response actions to address an existing odor problem. Table 2 includes the H₂S Action Levels that constitute an exceedance and a series of possible response actions.

The H₂S Action Levels are based on measured hydrogen sulfide levels in ambient air at the point of compliance established in a permit, plan or approval or the property boundary over specific time periods. Table 2 lists the H₂S Action Levels, what constitutes an exceedance and a series of possible response actions.

The Hydrogen Sulfide Action Levels are set at higher concentrations than the odor action threshold. Therefore, at most landfills with hydrogen sulfide emissions, landfill operators may need to begin assessing and mitigating hydrogen sulfide concentrations as a result of odor complaints and not as a result of an exceedance of the H₂S Action Levels because odors are detected at lower concentrations of H₂S. However, the H₂S Action Levels were selected as triggers for taking further actions at a landfill to control emissions of H₂S where there has not already been an exceedance of the odor threshold and to require the landfill operator to take actions before a condition arises that could impact public health.

The Action Levels listed in Table 2 are based on a review of monitoring data from Massachusetts landfills, review of exposure limits for hydrogen sulfide from various sources, and experience gained by MassDEP staff at landfills with odors and/or hydrogen sulfide emissions. The H₂S Action Level is a two-part level based upon either exceeding 15 ppb over an 8-hour period or 30 ppb over a 1-hour period. These levels were selected in order to capture longer term, low-level releases of H₂S, as well as shorter term spikes of H₂S. MassDEP's Office of Research and Standards is working to derive health-based guidance for short-term exposures to hydrogen sulfide in air. An implementation plan for the application and use of these guidelines needs to be developed. The development of the H₂S Action Levels and associated BMPs in this Odor Policy considered these values.

Table 1: Minimum Response Actions for Odorous Gas Emissions¹

Action Level	Averaging Time	Frequency of Exceedances Triggering Action	Defined Exceedance	Sampler/ Method Detection Limit Required	Action(s) To Be Taken by Landfill Operators Landfill operators will be required to have a site-specific Hydrogen Sulfide & Odorous Landfill Gas Response Plan (Response Plan) that will be followed in verifying, investigating and resolving all nuisance odors. The Plan should address the following activities:
Odor Action Level	Any	Odors of sufficient frequency, duration, intensity and odor characteristic (e.g. offensiveness) to be a nuisance off-site	Detection of nuisance odors offsite (Investigate and verify)	Public complaints, Board of Health, landfill personnel, ² MassDEP personnel, ambient air sampling	<ol style="list-style-type: none"> 1. Log the off-site complaint/detection of odors and contact local health officials and the Department within 24 hours. 2. Investigate the complaint to determine the source and extent of the odors to determine the severity of the odor problem (see Appendices). 3. Implement corrective actions, if necessary. 4. If the odor problem is not resolved quickly then consider whether to: <ol style="list-style-type: none"> a. cease acceptance of any material that has the potential to contribute to odorous landfill gas emissions, on at least a temporary basis; and/or b. place additional daily or intermediate cover soils or apply other cover technologies to reduce odorous landfill gas emissions to ambient air. 5. Conduct landfill gas monitoring if verified odors have not been traced to a particular source and resolved. 6. Conduct other activities as necessary and/or as directed by MassDEP to control nuisance odors (see 6, 7 and 8 in Table 2).

¹ In response to an odor problem at a landfill, MassDEP may require any and all actions necessary to resolve odor problems and to protect public health, safety and the environment.

² Landfill personnel should investigate complaints by following “*Recommended Protocol for the Assessment of Offsite Landfill Odors*” (refer to Appendix E)

Table 2: Minimum Response Actions for Exceedances of the H₂S Action Levels

Action Level	Averaging Time	Frequency of Exceedances Triggering Action	Defined Exceedance	Sampler/ Method Detection Limit Required	<p style="text-align: center;">Action(s) To Be Taken by Landfill Operators</p> <p>Landfill operators will be required to have a site-specific Hydrogen Sulfide & Odorous Landfill Gas Response Plan (Plan) that will be followed in verifying, investigating and resolving all H₂S exceedances. The Plan should address the following activities:</p>
H ₂ S Action Level (The action level is based upon either exceeding 15 ppb averaged over an 8 hour period or 30 ppb averaged over a 1 hour period)	8-hour	1	15 ppb or greater averaged over any 8-hour period ²	Continuous monitoring devices (e.g. hydrogen sulfide analyzer) sampling every ten minutes at a detection limit of 3 ppb	<ol style="list-style-type: none"> 1. Log the detection of any exceedances and contact local health officials and the Department within 4 hours for exceedances of the H₂S Action Level. 2. Investigate and determine the source and extent of the exceedance following the protocols in the appendices. If possible, correct the problem immediately. 3. Implement corrective actions, if necessary, including: <ol style="list-style-type: none"> a. cease acceptance of any material that has the potential to contribute to hydrogen sulfide emissions, on at least a temporary basis; and b. place additional daily and intermediate cover soils or apply other cover technologies to reduce hydrogen sulfide emissions to ambient air. 4. Implement 24-hour continuous air monitoring for hydrogen sulfide in ambient air, and daily near surface monitoring on the landfill. 5. Conduct additional ambient air monitoring off-site or evaluate need for additional off-site monitoring. 6. In addition, the following actions may be required if directed by MassDEP: <ol style="list-style-type: none"> a. Install a passive landfill gas control system (passive vents) that can be retrofitted to become an active gas collection and control system (combustion and/or non-combustion technologies); b. install an active landfill gas control system with landfill gas treatment (combustion and/or non-combustion technologies); c. evaluate the need for the installation of a final cover system with an active landfill gas control system on an expedited schedule. 7. Implement a Community Communications Plan, providing notification to the community and local medical/emergency response personnel that hydrogen sulfide concentrations, if they were to migrate off-site, may create an odor nuisance condition. 8. Conduct additional ambient air monitoring off-site to determine the hydrogen sulfide concentration at receptor locations.
	1 hour	1	30 ppb or greater averaged over any 1 hour period		

² Result based on a rolling average

VII. Hydrogen Sulfide and Odorous Landfill Gas Response Plan

A. General

Due to the potential threat of nuisance odors and potential risk to public health associated with hydrogen sulfide emissions, MassDEP will require investigations and response actions on an expedited schedule in response to an exceedance of an Action Level. The expedited schedule will be made possible, in part, by the advance preparation of a Hydrogen Sulfide and Odorous Landfill Gas Response Plan (the "Plan") (see Appendix C) by those landfill owner/operators identified in the Applicability section of this guidance. The development of this Plan is crucial to enable a quick assessment and abatement of hydrogen sulfide and other landfill gas emissions.

The Plan must include, at a minimum, steps to be taken to verify if there is an odor problem, assess a problem if one exists, identify receptors and determine what monitoring, response actions and communication should be taken in response to odor nuisances or concentrations of hydrogen sulfide in ambient air equal to or greater than the H₂S Action Level.

These procedures should be designed to allow the facility owners/operators to quickly investigate the potential cause of the odor that led to the complaint and immediately implement corrective actions. A Plan will formalize and build upon those procedures already in place at these landfills. Each landfill owner/operator that is required to submit a Plan (see Section III, Applicability) shall submit their site-specific Plan as part of the Authorization to Operate application, Major or Minor Permit Modification application, or Corrective Action Design application, depending upon the site-specific circumstances (BWP SW 22, minor permit modification application). Additional guidance regarding the preparation of the Plan is provided in Appendix C.

The Plan should include an Odor Survey Plan that identifies locations in the vicinity of the landfill that personnel assigned to investigate an odor complaint will visit to determine if odors are present and the nature of the odors. These locations should be selected based upon, but not limited to, the following criteria: proximity to the landfill, location of receptors, topography, meteorology, predominant wind direction, and other potential sources of odors and emissions. The landfill owner/operator will develop procedures and protocols for logging a complaint and investigating a complaint. Additionally, the landfill owner/operator will specify in the Plan when landfill gas monitoring is necessary and how the monitoring will be conducted and implement corrective actions should they be warranted. These procedures should be incorporated in the Hydrogen Sulfide and Odorous Landfill Gas Response Plan for the site. Refer to Appendix C, Appendix E and Tables 1 and 2 for additional guidance on the preparation of a Plan.

B. Assessment, Monitoring and Response Actions for Odor Action Level Events

Odor Action Level Event investigations and response actions are required upon the receipt of a complaint or detection of odors off-site at nuisance levels. In addition to off-site odors, landfill personnel should be cognizant of odors that exist on-site that have the intensity and duration to potentially migrate off-site. Therefore, each landfill owner/operator should take all necessary

actions as soon as possible when an odor is detected on site, even before a complaint is placed, to address the source of the odors.

In general, MassDEP expects the following verification, assessment, monitoring and response actions to be implemented in response to an off-site Odor Action Level Event. These steps are progressive steps that should be undertaken until the problem is resolved. It may not be necessary to take all steps to resolve an odor problem.

1. The landfill owner/operator will immediately log the complaint/detection of odors.
2. The landfill owner/operator will investigate the complaint to determine the source and extent of the odors following their Plan.
3. If odors are nuisance level odors, then contact local health officials and MassDEP within 24 hours.
4. The landfill owner/operator will implement the recommended management practices, as necessary to solve the odor problem, including, but not limited to:
 - a. cease acceptance of any material that has the potential to contribute to odorous landfill gas emissions, on at least a temporary basis; and
 - b. place additional daily or intermediate cover soils or apply other cover technologies to reduce odorous landfill gas emissions to ambient air.
5. The landfill owner/operator will conduct landfill gas monitoring if verified odors have not been traced to a particular source and remedied or where required by MassDEP.
6. The owner/operator shall conduct additional investigations including, but not limited to, landfill gas characterization, emission monitoring, near-surface landfill gas monitoring and ambient air monitoring (refer to Appendix B, Landfill Gas Monitoring) or where required by MassDEP. This monitoring shall be performed to determine the nature, source and extent of the emissions ongoing at the landfill site.

The owner/operator shall implement progressively more comprehensive corrective actions as necessary until nuisance odor conditions are resolved at the site. Please refer to the H₂S Action Level for possible additional response actions. Also, persistent nuisance odor conditions that result in non-compliance with the regulations may result in MassDEP taking enforcement.

C. Assessment, Monitoring and Response Actions for H₂S Action Level Events

H₂S Action Levels are only applicable where a facility has been specifically required by MassDEP in a permit to monitor for H₂S or has been monitoring for H₂S in accordance with its Hydrogen Sulfide and Odorous Landfill Gas Response Plan. The H₂S Action Levels for hydrogen sulfide are listed in Table 2, along with information on recommended sampling equipment, averaging times, what constitutes an exceedance of the Action Levels and associated response actions. In order to determine if a Hydrogen Sulfide Action Level has been exceeded, air monitoring equipment must be employed. MassDEP recommends that continuous monitoring devices be used with the detection limits in the range of single parts per billion. Most continuous monitoring devices can be adjusted to collect readings on a set time interval (every few minutes-hours). MassDEP recommends that the meter initially be set to collect hydrogen sulfide readings every 10 minutes. Appendix B –Landfill Gas Monitoring - includes basic information about the design and implementation of ambient air monitoring at landfills. However, this document does

not focus on how to conduct air monitoring and MassDEP recommends that professionals experienced with ambient air monitoring procedures and protocols be consulted.

The landfill owner/operator will implement assessment, monitoring and response actions in accordance with this policy and an approved site-specific Plan when hydrogen sulfide concentrations in ambient air are greater than or equal to the H₂S Action Level to comply with 310 CMR 19.117, 19.130, 7.01 and 7.09. In general, MassDEP expects the following verification, assessment, monitoring and response actions to be implemented in response to a H₂S Action Level Event. These steps are progressive steps that should be undertaken until the problem is resolved. It may not be necessary to take all steps to resolve an odor problem.

D. General Conditions for the H₂S Action Level

1. In order to have an exceedance of the H₂S Action Level, the following two criteria must be satisfied:
 - a. Hydrogen sulfide must be detected in ambient air at or beyond the point of compliance (POC) (usually the property boundary) established in a permit, plan or approval; and
 - b. The average concentration of hydrogen sulfide measured in ambient air at this location must be greater than or equal to 15 ppm averaged over 8 hours or 30 ppb averaged over one hour.
2. MassDEP expects the following initial response, assessment and monitoring activities will be implemented by the landfill owner/operator when hydrogen sulfide concentrations in ambient air are greater than the H₂S Action Level:
 - a. Immediately log the detection of any exceedances and contact local health officials and the Department within 4 hours for exceedances of the H₂S Action Level.
 - b. Investigate and determine the source of the exceedance following the protocols in the Plan.
 - c. Immediately:
 - i. cease acceptance of any material that has the potential to contribute to hydrogen sulfide emissions, on at least a temporary basis.
 - ii. place additional daily and intermediate cover soils or apply other cover technologies to reduce hydrogen sulfide emissions to ambient air.
 - d. Conduct additional ambient air monitoring off-site or evaluate the need for additional off-site monitoring.
 - e. Implement 24-hour continuous air monitoring for hydrogen sulfide in ambient air and daily near surface monitoring on the landfill.
3. The following progressive Corrective Actions will be implemented by the landfill owner/operator when hydrogen sulfide concentrations in ambient air are greater than the H₂S Action Level as directed by MassDEP on a case-by-case basis depending on site-specific factors:

- a. Install a passive landfill gas control system (passive vents) that can be retrofitted to become an active gas collection and control system (combustion and/or non combustion technologies).
 - b. Evaluate the need for the installation of a final cover system with an active landfill gas collection and control system on an expedited schedule.
4. Implement a Community Communication plan, providing notification to the Community and local medical/emergency response personnel that hydrogen sulfide concentrations, if they were to migrate off-site, may create an odor nuisance condition.
5. In addition to the activities required above, the landfill owner/operator will implement the additional Assessment and Monitoring and Corrective Actions specified below when directed by MassDEP.
 - a. Install a cap with an active landfill gas collection and control system.

VIII. Recommended Management Practices

MassDEP requires that landfill operators incorporate procedures and practices that will prevent potential impacts to air quality and nuisance conditions from developing at the facility. MassDEP refers to these procedures and practices as Recommended Management Practices (“RMPs”). In the context of this Policy, a RMP is a preventive technology or measure that is implemented to limit potential impact to air quality by a landfill and to address nuisance and public health concerns. The RMPs discussed in this guidance are designed to prevent and/or reduce the potential impact from hydrogen sulfide and odorous landfill gas emissions. These RMPs may evolve over time and the landfill owner/operator may be required to take further actions beyond the RMPs to resolve persistent odor problems or H₂S problems at a landfill. The RMPs discussed below are summarized in Table 3.

A. Active Face and Cover Materials

1. Active Face

The operator should carefully evaluate the size of the active face, generally trying to keep it as small as possible as this will limit the surface area of exposed waste, both reducing the potential for odor as well as limiting the area needing cover soils.

2. Cover Materials

The type and quantity of cover materials should be selected with odor control in mind. Soil daily cover materials may need to be placed more frequently than once a day and the effective quantity to control odor may be more than the minimum 6 inches required by regulation.

Table 3. Recommended Management Practices	
BMP	Suggested Practice
Active Face	<ul style="list-style-type: none"> • Evaluate size of active face • Keep as small as possible to limit surface area exposed and need for cover material • Provide good compaction and proper grading to reduce infiltration of storm water into waste
Cover Materials	<ul style="list-style-type: none"> • Select the type and quantity of cover material to control odors • Evaluate the need to place cover material more than once per day • Evaluate the need to apply greater than 6 inches of cover material • Provide good compaction of cover material to reduce chances of odor “breakouts” • Consider use of synthetic spray-on materials to help control odors more effectively • Consider use of lime-based products, which can neutralize odors • Evaluate the frequent use of intermediate cover, which can be effective for controlling odors
Sequencing Plan	<ul style="list-style-type: none"> • Plan carefully for the location, sizing and timing of placement of waste and cover materials • Bring active areas to grade quickly, then place final cover and gas controls on newly completed areas
Gas Collection and Control Systems	<ul style="list-style-type: none"> • Develop a contingency plan for installing an active gas collection and control system, including, where necessary, hydrogen sulfide pre-treatment systems that are appropriately sized to pre-treat the volume of gas generated • Install gas control system during active landfilling where possible: <ul style="list-style-type: none"> ○ Include sacrificial, horizontal, perforated gas collection pipes ○ Install gas extraction wells prior to placement of final cover • Passive system should be designed to be retrofitted and operated as an active system within short period of time • Include sufficient funding in the facility’s Financial Assurance Mechanism to ensure proper operation and maintenance of the gas collection and control systems during the life of the facility and the post-closure period
Gas Collection and Control System Operations	<ul style="list-style-type: none"> • Provide proper training for all landfill operators • Provide routine balancing of the active gas collection and control system well-field • Provide routine monitoring and maintenance, including monitoring of and change-out of media in sulfur pre-treatment systems as needed • Conduct routine inspections of the collection system for settlement, leaks and condensate levels • Check water levels within gas wells to ensure well screens are not blocked
Gypsum Removal	<ul style="list-style-type: none"> • If using C&D Fines or C&D Residuals at the landfill, only accept C&D materials from facilities that remove gypsum materials from the C&D • Gypsum should be removed from the C&D material prior to any processing of the remaining C&D materials • C&D processing facility should provide landfill with verification that gypsum has been removed
Mixing Ratios: Soil and C&D Debris Fines and Residuals	<ul style="list-style-type: none"> • Mix soils with fines or residuals to reduce the generation of hydrogen sulfide <ul style="list-style-type: none"> ○ Consider the use of coal ash and wood ash to reduce odors • C&D fines and residuals must be mixed with soils at a ratio of at least 3 parts soil to 1 part C&D fines or residuals by volume • Cover all C&D fines or residuals at the end of the working day

Some synthetic spray-on cover materials may both create a more gas tight surface as well as have components that can act as odor neutralizing agents, such as lime-based products.

Intermediate cover may prove to be an effective odor control method and its use should be considered on a more frequent basis than the minimum regulatory requirement of placing intermediate cover when waste will be left exposed for more than 30 days.

B. Sequencing Plan

Attention to the landfill's sequencing plan – the location, sizing and timing of placing waste and cover materials – can help control landfill gas emissions by bringing active areas up to grade quickly and placing final cover and landfill gas controls on newly completed sections of the landfill.

C. Gas Collection and Control Systems³

At a minimum, a contingency plan for installing a landfill gas collection and control system, including H₂S pretreatment, as necessary, should be part of a landfill's approved operating permit. Consideration should be given to evaluating the use of a gas collection and control system that can be installed during active landfilling (sacrificial active gas systems, candle stick flares, etc.) instead of only implementing landfill gas controls as part of the final cover system. Please note that any passive gas system should be designed to be retrofitted and operated as an active gas collection and treatment system within a short period of time in the event that odors or H₂S issues develop.

Sufficient resources to ensure the proper operation of a landfill gas collection and treatment system can also be a critical factor in the successful operation of a landfill gas and odor control system.

D. Gypsum Removal

The landfill owner/operator should only accept construction and demolition (C&D) materials from C&D processing facilities that have implemented an aggressive program for the separation and removal of gypsum materials from the C&D. The gypsum removal should occur prior to processing. The C&D processing facility should furnish the landfill owners/operators with verification that gypsum has been removed prior to acceptance of this material either for disposal or grading and shaping.

E. Mixing Ratios: Soil and Construction and Demolition Debris Fines and Residuals

MassDEP recommends that soil be mixed at a minimum rate of three parts soil to one part construction and demolition debris ("C&D") fines and residuals measured by volume. MassDEP has reviewed different methods to accomplish this mixing, taking into consideration operations

³ Landfills subject to NSPS Subpart WWW (have a design capacity greater than 2.5 million Mg (2.75 million tons)) and with NMOC emissions greater than 50 Mg/yr are required to have a gas collection and treatment system (refer to Appendix F).

at both active landfills and closure operations at unlined landfills. The method that was most successful consisted of placing and spreading C&D fines and/or residuals within the active area, approximately one foot thick. Then soil, a minimum of one foot thick, is placed and spread over the C&D fines/residuals, followed by "tracking" with a bulldozer to thoroughly mix the soil into the C&D fines/residuals. Next, two more one foot thick soil layers are spread and tracked. Finally, the area is compacted and covered with other cover materials as may be necessary to control odors or other nuisance conditions. In addition, other materials may be useful in reducing odors when mixed with fines and residuals, including coal ash and wood ash.

IX. Appendices

The appendices listed below are intended to facilitate the development of the hydrogen sulfide and odor management plans and components.

- Appendix A - Basics of Landfill Gas (Methane, Carbon Dioxide, Hydrogen Sulfide and Sulfides)
- Appendix B - Landfill Gas Monitoring
- Appendix C - Checklist for Hydrogen Sulfide and Odorous Landfill Gas Response Plans
- Appendix D - Action Level – Data Collection and Action Level Exceedance Examples
- Appendix E - Recommended Protocol for the Assessment of Off-Site Landfill Odors
- Appendix F - Health and Safety Issues Associated with Hydrogen Sulfide
- Appendix G - Landfill Gas Control Technologies
- Appendix H - Frequently Asked Questions

Mention of trade names or commercial sources in this guidance document is for identification purposes only and does not imply endorsement or recommendation by MassDEP.