MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

# Development on or Near Methane Generating Sources

This document was developed by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Remediation and Redevelopment Division to promote a consistent and informed approach for development on and near methane generating sources.

This document provides information and guidance to EGLE staff, contractors, and other parties making risk management decisions when methane is or may be present. It is explanatory and does not contain any regulatory requirements. It does not establish or affect legal rights or obligations. It does not have the force or effect of law and is not legally binding on the public or the regulated community. Any regulatory decisions made by EGLE regarding methane will be made by applying the governing statutes and relevant Administrative Rules.

Approved:_____

Mike Neller, Director
Remediation and Redevelopment Division
April 10, 2025

This publication is intended for guidance only and may be impacted by changes in legislation, rules, policies, and procedures adopted after the date of publication. Although this publication makes every effort to guide users how to meet applicable compliance obligations, use of this publication does not constitute the rendering of legal advice.

EGLE does not discriminate on the basis of race, sex, religion, age, national origin, color, marital status, disability, political beliefs, height, weight, genetic information, or sexual orientation in the administration of any of its programs or activities, and prohibits intimidation and retaliation, as required by applicable laws and regulations.

Individuals with disabilities may request this material in an alternative format by emailing EGLE-Accessibility@Michigan.gov or calling 800-662-9278.

# CONTENTS

Purpose ..... 1
1.0 Background ..... 2
1.1 Methane Sources ..... 2
1.2 Methane Migration ..... 3
2.0 Current and Future Site Conditions ..... 3
2.1 Conceptual Site Model ..... 3
2.2 Communication and Stakeholder Engagement ..... 4
2.3 Impact of Development and Proposed Use ..... 4
3.0 Land Use Categories ..... 5
4.0 Methane Action Levels ..... 6
5.0 Professional Experience ..... 8
6.0 Methane Mitigation System Requirements ..... 8
6.1 General Mitigation System Design Requirements ..... 9
6.2 General Building Construction Considerations ..... 9
6.3 General Mitigation System Components ..... 10
6.4 Passive Mitigation Systems ..... 11
6.5 Active Mitigation Systems ..... 12
6.6 Podium Style Construction Mitigation ..... 13
6.7 Overall Site Mitigation ..... 14
6.8 System Start Up / Commissioning ..... 14
6.9 Submittals to EGLE ..... 14
7.0 Inspection, Maintenance, and Monitoring ..... 15
8.0 Institutional Controls and Assurances ..... 16
Attachment 1. Methane Soil Gas Action Levels and Mitigation System Requirements ..... A1-1
Attachment 2. Site Characterization and Developing a Conceptual Site Model for Methane Sites ..... A2-1
1.0 Development And Submittal of Methane CSM ..... A2-2
2.0 Detailed Sampling Program Design ..... A2-9
Attachment 3. Acknowledgements And References ..... A3-1

# Purpose

EGLE recognizes that methane sites are fundamentally different from other vapor intrusion sites and require separate guidance. Methane gas has proven to pose a potentially serious public health and safety risk. Fires and explosions, resulting in significant property damage, have occurred in cases where methane gas has migrated into structures or other areas where ignition sources are present. As property development pressures increase across Michigan, the likelihood of future concerns about development on and near methane generating sources (MGS) will also increase.

The regulatory authority over methane sources is shared among various divisions of EGLE. This guidance was developed by the Remediation and Redevelopment Division (RRD) to address development projects on or near a MGS. It applies whenever EGLE approval is being sought for development projects, including both new construction and redevelopment of existing structures where methane is or could be a concern as described in Section 1.1, Methane Sources. The action levels by land use category and recommendations for mitigation should also be considered when performing response activities or to comply with due care.

The guidance is primarily focused on identifying and mitigating risks associated with methane as it relates to the volatilization to indoor air pathway (VIAP) and fire and explosion hazard.

The goals of this guidance are to:

- Provide consistency and clarity for EGLE-RRD (department) staff, contractors, practitioners, and the regulated community.
- Provide methane action levels based on proposed property use.
- Provide guidance regarding site characterization and development of conceptual site models at sites where methane is a concern.
- Provide design and commissioning requirements for methane mitigation systems (MMS).
- Provide guidance on the documentation, inspection, and maintenance of installed systems.

Each site may represent a unique situation involving a variety of existing conditions, land uses, development plans, and operations. It is expected that practitioners and department staff will utilize professional judgement that may result in a range of interpretations on the application of this guidance to the specific site conditions.

Note that this document does not address nor waive any applicable local, state, or federal requirements necessary for site development. It is recommended that input from local health, building and construction, and fire departments be sought and incorporated into planned site developments.

Alternate approaches not specifically covered in this guidance may also be acceptable and will need to be reviewed and approved by EGLE for long-term effectiveness and protection of human health.

# 1.0 Background

Methane ($CH_4$) is the lightest of all hydrocarbons (specific gravity 0.555) and diffuses very rapidly in air. It is a colorless, odorless, tasteless, flammable gas that is generated as a result of the microbial or thermal alteration of organic matter. According to U.S. EPA's Climate Change Indicators: Atmospheric Concentrations of Greenhouse Gases document, the baseline background concentration of methane in the atmosphere is 1.7 parts per million by volume (ppmv). Methane is not toxic and is not known to have systemic toxicological effects. The principal concerns with methane are its explosiveness, flammability, and asphyxiant properties.

Methane concentrations in the subsurface above the UEL or 15 percent by volume should be considered the most dangerous, since such concentrations can dilute to explosive levels when entering enclosed spaces such as buildings, crawl spaces, utilities, wells, etc.

Since methane is not toxic, no threshold limit value (TLV), permissible exposure limit (PEL), or recommended exposure limit (REL) values have been established. Fire and explosion can result if methane accumulates in a confined space at concentrations between 5 and 15 percent by volume in air (50,000 to 150,000 ppmv), oxygen is present, and an ignition source exists (e.g. electrical outlets, appliances, static electricity, pilot lights, or open flames). Five percent by volume (50,000 ppmv) is the lower explosive limit (LEL) whereas 15 percent by volume (150,000 ppmv) is the upper explosive limit (UEL) for methane.

## 1.1 Methane Sources

Methane is widely distributed in nature and the atmosphere. It is typically generated in the subsurface due to the anaerobic decay of both naturally occurring and man-made organic sources. Naturally occurring sources include decaying organic matter contained in wetlands, rivers, lakes, sediments, and peat bogs. Man-made sources may include, but are not limited to, regulated landfills, non-regulated dumps, sewer lines, septic systems, oil and natural gas transmission and distribution lines, hydrocarbon contamination, and organic fill material (e.g. sawdust and wood).

This document is primarily focused on man-made methane source sites (landfills, dumps, fill areas, hazardous substance releases) where methane is produced from degradation of organic matter under anaerobic subsurface conditions. However, many concepts presented in the document may also be applied to naturally occurring methane. Methane generation can begin in-situ over days to years and persist for decades based on both the nature of the methane source and the subsurface site conditions including moisture, temperature, and physical setting.

### Landfills and Dumps

Both landfills and dumps are waste disposal locations. However, regulated landfills require permits to build, whereas dumps are unregulated solid waste disposal sites. Methane concentrations at landfills and dumps are influenced by the *moisture content* (stormwater infiltration, snowmelt, contact with groundwater) and *type of waste* (organic content of the waste). A permitted landfill is constructed and filled using proper waste placement and compaction, and filling operations often account for specific waste types. Modern permitted landfills are capped with impermeable covers to limit the amount of moisture entering the waste. Unpermitted dumps may be constructed with insufficient compaction, no cover or a substandard cover, and comingled waste types. Additionally, unpermitted dumps were often constructed in floodplains or wetlands, which may increase methane production.

The rate of methane generation that occurs at these types of sites can often exceed the rates that methane can escape into surrounding soil and the atmosphere. This can result in pressure-driven (advective) flow into overlying or nearby buildings.

### Methane Generating Source Material

Methane generating source material is defined as subgrade soil, waste, groundwater, or other material that is actively generating methane above 25% of the LEL. Representative soil gas sampling can be utilized to show the soil, waste, groundwater, or other material is not generating methane above 25% of the LEL and therefore would not be considered a MGS material.

## 1.2 Methane Migration

Methane can migrate laterally and vertically through the subsurface. Methane gas will move through the unsaturated soil column via diffusion and advection and can follow preferential pathways. Methane can also be present in groundwater, which can be a mechanism to transport methane to receptors. It is difficult to predict the distance that methane will travel because so many factors such as site geology and grades, preferential pathways, dissolved methane in groundwater, and the proposed development plan, affect its ability to migrate underground. This issue is discussed in greater detail in Attachment 2. Site Characterization and Developing a Conceptual Site Model for Methane Sites (Attachment 2).

# 2.0 Current and Future Site Conditions

## 2.1 Conceptual Site Model

The presence of waste material alone does not constitute a methane source. Similarly, the presence of methane at low concentrations may not constitute a threat of an explosion. The threats associated with methane intrusion should be assessed quantitatively, considering factors such as migration pathways, potential impacts on human health and safety, soil gas concentrations, and differential pressures.

A thorough understanding of current site conditions is crucial in determining the potential risks of the site and if those risks can be adequately addressed for the proposed reuse. This is accomplished by development of a conceptual site model (CSM) and data collection to support or modify the CSM. Development of a CSM is discussed further in Attachment 2.

## 2.2 Communication and Stakeholder Engagement

Prospective developers and communities interested in developing methane sites of concern should reach out to EGLE early in the planning process. Early communication during the planning process can help ensure all parties have a clear understanding of expectations, timeframes, and EGLE requirements.

Because of the complex nature of these projects, it is important to communicate findings, address concerns, and facilitate decision-making with all stakeholders. This includes not only EGLE, but also other regulatory agencies, local communities, liable parties, landfill operators, and other potentially affected parties.

## 2.3 Impact of Development and Proposed Use

Development projects will inevitably include changes in the surface cover, such as buildings and parking lots. This increased cover may inhibit soil air exchange and has the potential to create conditions that could promote methane migration where such conditions may not have previously existed. This potential effect should be evaluated as part of the design process. Evaluation of the potential for methane migration can be accomplished by installing methane monitoring points around the outside of the development and monitoring them pre and post development to ensure that they stay below 25% of the LEL.

Often the best use of land containing a former dump or landfill is to leave the property as open, green, or recreational space. In general, building structures on or near a methane producing dump or landfill is not recommended. If structures are proposed, land uses such as warehousing or industrial may be more appropriate than more sensitive uses.

EGLE generally does not recommend development at methane producing former dump or landfill sites for sensitive uses such as residential, schools, daycare centers, or similar uses.

For what can be supported by EGLE refer to Attachment 1.

## 3.0 Land Use Categories

Development of contaminated property requires evaluation and mitigation of risks posed by the contamination. The more sensitive the proposed use, the more robust the requirements for evaluation and mitigation.

For purposes of this guidance, the 3 major land use categories established include General Residential, Managed Multi-family Residential, and Non-Residential. In addition, 2 distinct subcategories are provided for General Residential use, based on the relation of the proposed structure(s) to the edge of the MGS material. A summary of all categories is provided below.

A. **General Residential** – Includes rented or owned single family homes and townhomes, condominiums with or without a homeowner's association (HOA), etc.

   A.1 **General Residential - Category 1**. Includes structures within 200 feet from the edge of the MGS material.

   A.2 **General Residential - Category 2.** Includes structures greater than 200 feet from the edge of the MGS material.

B. **Managed Multi-family Residential** – Includes apartments and other multi-family rental or lease properties where a property management company maintains and manages the property. This category also includes schools, hotels, hospitals, day care facilities, and other similar uses.

C. **Non-Residential** – Includes industrial manufacturing operations engaged in processing and manufacturing of materials or products, utility companies, industrial research and development, and petroleum bulk storage. Commercial uses that are also considered non-residential include any business, retail, or income-producing use such as warehouses, lumber yards, retail gas stations, office buildings, medical or dental offices (not including hospitals), restaurants, health clubs, beauty salons, etc.

Please note that the 200-foot distance from MGS material described above should not be confused with the concept of a lateral inclusion zone. The 200-foot distance is specifically incorporated into the definition of the General Residential land use category to address residential development in proximity to MGS material.

Land uses not specifically described above, such as recreational, will be evaluated on a site-specific basis. Contact the department for assistance.

As described in Section 2.1 and Attachment 2, development of a CSM is required to understand all site conditions and the risks they pose. As more information regarding specific site conditions is gathered, the acceptable minimum and maximum distances from methane generating material may be either increased or decreased. This topic is discussed in detail in Section 1.3 of Attachment 2.

# 4.0 Methane Action Levels

Methane has the potential to pose an acute risk. This document provides guidance for methane mitigation based on factors including methane soil gas concentration, differential pressure, proposed development type, and proximity to a MGS. Within this guidance, sites with residential or other sensitive land uses have more robust mitigation system requirements.

It should be noted that methane concentrations are commonly expressed in three different ways, % of the LEL, % by volume, and ppmv. This can add confusion when comparing data to action levels. Table 1 shows the various means of expressing methane concentrations and how they equate.

**Table 1. Methane concentration equivalents**

| PPMV | % by Volume | % of the LEL |
|---|---|---|
| 5,000 | 0.5% | 10% |
| 12,500 | 1.25% | 25% |
| 25,000 | 2.5% | 50% |

The Part 201 methane screening level is based on 25% of the LEL, which was determined to be an acceptable soil gas concentration for both residential and nonresidential land uses. EGLE's screening level of 25% of the LEL was utilized in the development of the methane action levels provided in this document. Indoor air methane concentrations approaching the LEL usually result from pressure-driven advective flow of methane, rather than diffusion. Therefore, evaluation of the methane intrusion threat to potential receptors requires consideration of both concentration and pressure. This differs from most volatile organic compounds (VOCs), where the concentration present in soil gas is directly related to the potential vapor intrusion risk.

Methane soil gas action levels are provided in *Attachment 1- Methane Soil Gas Action Levels and Mitigation System Requirements* (Attachment 1). The action levels specify methane mitigation requirements based on the proposed land use category at maximum concentrations and differential pressures identified within the development area. The maximum observed pressure and methane concentration should be compared to the action levels in Attachment 1 to establish what monitoring or mitigation measures are required for the planned development. For multi building developments, applicability of this guidance can be assessed for each structure, provided that proposed changes in site conditions (e.g. paving/addition of pervious surfaces) are factored into the CSM.

A few general takeaways from Attachment 1 include the following:

- **Regardless of land use**, no actions are required when it can be demonstrated that the maximum subsurface methane vapor concentrations are at or below 25% of the LEL and the maximum measured differential pressures are confirmed to be below 0.25-inches of water.

- **General Residential use** may be considered for methane concentrations greater than 25% of the LEL when podium style construction is proposed.
- **Managed Multi-family Residential use** may be considered for methane concentrations greater than 25% of the LEL when podium style construction or active MMS is proposed.
- **Regardless of land use,** when maximum subsurface methane vapor concentrations are below 25% of the LEL and maximum measured differential pressures are greater than 0.25-inches of water, additional monitoring will be required to understand the long-term trends and evaluate the potential threats. The required remedial actions will depend on having sufficient data to understand the methane concentration and pressure trends, to more accurately evaluate the threat. This additional monitoring data could in some cases result in no required remedial actions, while in other cases it may result in the need for the design and installation of an MMS.

Alternatives and exceptions to the Attachment 1 requirements can be proposed and will be evaluated by EGLE on a case-by-case basis.

To consider these proposals, EGLE must be satisfied that the CSM and site characterization is sufficiently complete to make this determination. See Attachment 2 for CSM discussion.

Because of the hazards posed by methane, its inherent variability, and the need to ensure that public health, safety, and welfare are adequately protected, indoor air action levels for methane have also been developed. In general, any detection of methane in the indoor air should trigger an inspection of the MMS, as it indicates that the system may not be working. If methane is detected at 10% of the LEL or greater, evacuation of the building should be implemented until the condition can be rectified. The indoor air action levels and suggested response actions are provided in the following Table 2.

**Table 2. Recommended Action Levels and Responses for Methane in Indoor Air**

| Methane Level | Recommended Actions |
|---|---|
| 0.2% of the LEL to 1% of the LEL (100 – 500 ppmv) | • Identify and address sources of methane (natural gas leak, sewer gas, external, etc.)<br>• Seal any identified points of entry<br>• Install methane detectors, if not already in use |
| 1% of the LEL to 10% of the LEL (500 – 5,000 ppmv) | • Implement above actions<br>• Ventilate structure<br>• Implement exterior investigation, as appropriate |
| >10% of the LEL (5,000 ppmv) | • Implement above actions<br>• If concentrations can't be mitigated immediately:<br>  ○ Evacuate structure<br>  ○ Notify Fire Department<br>• Identify additional mitigation measures needed to address future risks |

# 5.0 Professional Experience

Persons applying this guidance are expected to be knowledgeable in the assessment, mitigation, and engineering practices applicable to the methane sites of concern. Submittals to EGLE must include documentation demonstrating the expertise of the environmental consultant(s) or professional engineer(s) in safely assessing, mitigating, or developing similar methane projects.

Persons designing and implementing MMS are responsible for ensuring that the design, installation, construction, permitting, monitoring, and maintenance activities are performed and/or certified by persons with demonstrated experience with similar methane related projects. Mitigation system plans submitted to EGLE for approval must be signed and sealed by a professional engineer licensed in the State of Michigan.

# 6.0 Methane Mitigation System Requirements

As discussed in Section 4.0 and Attachment 1, the need for a mitigation system is dependent on the maximum measured methane concentrations and pressures and the proposed land use. Design of an MMS requires a robust CSM that provides an understanding of the site conditions. Once the site has been properly characterized and found to need a MMS, the design, installation, and operation of the system should be done in accordance with the requirements provided below.

## 6.1 General Mitigation System Design Requirements

General requirements that apply to all MMS designs should include:

- All applicable information from Volume 5, Response Actions, of EGLE's Guidance Document for the Volatilization to the Indoor Air Pathway, which includes, the Active or Passive Vapor Mitigation System Table of Contents (VIMTOC) document, respectively.
- An applicable vapor barrier incorporated into any methane mitigation design for new construction. However, if construction style is used as the mitigation strategy (e.g. podium style construction), a vapor barrier may not be required.
- Continuous combustible gas monitoring devices equipped with an alarm in mitigated structures.
- Intrinsically safe mechanical and electrical components of a methane mitigation system exposed to the captured soil gas.
- Labeling of mitigation piping in the structure to ensure occupant safety.
- All methane mitigation systems must be designed and sealed by a State of Michigan licensed professional engineer as provided in Section 5.0.

## 6.2 General Building Construction Considerations

Methane considerations go beyond the mitigation system alone, which is why it is important to enlist the services of a licensed professional engineer experienced with methane mitigation design and construction of buildings that may be impacted by methane. Construction-related considerations for methane sites should include, but are not limited to, the following:

- Measures to ensure that all work in construction plans and undertaken by contractors conforms with and maintains the integrity of the mitigation design.
- Inspection and proper installation of mitigation system components before covering with structural elements, as appropriate.
- Designs incorporated into the MMS to manage the potential for the foundation to adversely affect system performance.
- Proper incorporation of the mitigation system components and proper installation of the vapor barrier or aerated floor components in the building foundations and footers. Some foundation components such as grade beams or thickened slab areas may inhibit system performance. Additionally, aggregate piers may act as conduits for the migration of methane if the aggregate used is more transmissive and more permeable than the surrounding soil.

- Appropriate sealing of all penetrations of the foundation and mitigation system (for utility lines, etc.) and evaluation of accessible penetrations on a routine basis as part of the on-going operation, maintenance, and monitoring program.
- Special provisions and considerations to isolate buried utility lines from methane generating material and prevent the utility corridors from becoming pathways for methane migration. Utility corridors and trenches should be lined and/or sealed to reduce potential for methane migration into on-site structures and to off-site receptors. Some subsurface utilities may require flexible joints to prevent cracking and breakage due to waste settlement. It may be possible for some utilities such as telephone and electrical to enter the structure from above ground to prevent creating a subsurface utility corridor vapor migration pathway.
- Clean soil backfill in buried utility corridors and/or locating utility corridors in a manner that ensures that future repair work will be unlikely to encounter waste materials.
- Vapor barriers must be compatible with methane as well as any other volatile organic compounds of concern that are present and could pose a risk. Post installation testing must be conducted to ensure the barrier is adequately seamed and sealed to foundations and utility penetrations.

## 6.3 General Mitigation System Components

This section provides details on some key components of a methane mitigation system. This is not intended to be a design guide or to provide a prescriptive approach to methane mitigation, rather this provides some general information on components used in methane mitigation systems. In general, the components listed below should be incorporated in both passive and active mitigation systems. Additional components beyond that which are outlined herein will likely be needed and should be incorporated into the design. The designer must be a licensed professional engineer experienced in methane mitigation system design development.

### Physical Vapor Barrier Systems

The purpose of a vapor barrier system is to address potential leaks in a building slab that would otherwise allow for migration of the sub-slab soil gas into the indoor air of a structure. Because concrete slabs have numerous locations where leaks can occur (such as joints, cracks, penetrations, etc.) the addition of a barrier below the concrete slab is important for reducing those leaks. One of the most important components of a vapor barrier system are the seals at joints and penetrations and/or holes caused by damage during installation. Construction Quality Assurance should be completed and documented during vapor barrier installation to ensure that the vapor barrier is installed as designed.

Vapor barriers must be compatible with methane as well as any other volatile organic compounds of concern that are present and could pose a risk. Testing must be conducted to ensure the vapor barrier is adequately seamed and sealed to foundations and utility penetrations. The performance of these systems is typically verified by performing a smoke test under the barrier after installation, but prior to placement of the concrete slab.

### Sub-Slab Permeable Layer and Piping

Mitigation systems ideally include a permeable layer below the slab. The purpose of this permeable layer is to promote efficient transmission of the sub-slab soil gas to the vent riser pipes. The permeable layer can consist of clean gravel, aerated floor elements (e.g. Cupolex® forms), or geocomposite material. When using gravel, the material should be generally free of fines, durable, and not subject to deterioration. Michigan Department of Transportation (MDOT) gravel 21AA should not be used as the venting layer, as it generally contains excessive fines. When aerated floor elements are used, a vapor barrier may only be needed in strategic locations (e.g. pipe penetrations, slab joints, and other areas prone to leaks).

Depending on the configuration of the foundation and approach to mitigation, sub-slab piping may be needed to promote airflow below the slab.

Vertical “riser” pipes should be included in mitigation system designs to allow for extraction of sub-slab soil gas.

## 6.4 Passive Mitigation Systems

Passive mitigation systems rely on a combination of vapor barriers and passive venting to stop methane from migrating into a structure. Common approaches include the use of vapor barriers, venting layers, and air inlet and extraction pipes.

Passive systems have fewer moving parts and are not expected to have consistent flow or vacuum, so there are less things to monitor and measure over time. As a result, passive performance is often demonstrated by smoke testing and should confirm the following:

- Flow or connectivity from all portions of the floor to the vertical vent risers
- Flow up through the vertical vent risers
- The barrier prevents advective and diffusive flow into the structure via smoke testing, tracer gas, or indoor air sampling

Confirming the operation of the passive mitigation system should also include the use of any meter or alarms (e.g. methane alarms) that have been installed to verify that methane is not in the indoor spaces.

In many cases, passive systems are designed with an option to be converted to an active system, should it become necessary. This is typically triggered when there is evidence that methane is or could make it past the passive system such as alarms being activated, failed testing, or evidence of open seams or damage to the vapor barrier.

Passive systems can be effective for new construction but are more difficult to implement and less likely to meet performance criteria in existing structures.

## 6.5 Active Mitigation Systems

Active mitigation systems, which include sub-slab ventilation (SSV) or sub-slab depressurization (SSD), rely on the use of intrinsically safe electric fan(s) to pull soil gas from below the building slab and vent it to the atmosphere.

Active SSV works similarly to passive sub-slab venting, except that the venting rate is controlled using intrinsically safe electric fan(s). Active SSV systems should include a permeable sub-slab venting layer or aerated floor, vapor barrier (new construction), riser pipes, and intrinsically safe electric fans. Performance monitoring of SSV systems can be documented by monitoring system flow rates with sub-slab methane screening and occasional riser pipe methane screening. The expected performance of a SSV system would be to effectively reduce the methane concentrations in the sub-slab below screening levels. The use of SSV is an effective component of mitigation systems for new buildings or major renovations where the existing slab will be removed. SSV is typically not considered to be an effective technology for retrofits, unless the sub-slab is permeable. Additionally, if SSV is used as a mitigation approach, air inlet piping should be included to provide fresh air to the sub-slab and enhance the ventilation.

Active SSD operates by applying a vacuum (negative pressure) relative to indoor air beneath the building slab, so that advective air flow across the slab is down or from indoor to sub-slab. Sub-slab methane concentrations with SSD can be higher than screening levels, since the soil gas will not adjectively enter the structure. SSD is a common approach to methane mitigation in both new and existing buildings, particularly where methane concentrations are present, but elevated pressure differentials are not observed. Performance monitoring of SSD systems can be documented by monitoring the pressure differential across the slab and ensuring that a vacuum is maintained.

Active mitigation is designed to create subsurface air flow and vacuums. When designing an active mitigation system, consideration and evaluation should be made to ensure that the active mitigation system does not alter the advective transport that would result in methane migration to any unmitigated structure(s).

Requirements for active systems include intrinsically safe components and visual and audible alarms when systems components fail or have been shut down. The use of solar and wind powered fans are not typically considered for active mitigation approaches.

## 6.6 Podium Style Construction Mitigation

Podium style construction is an approach to development that incorporates non-enclosed open-air space such as parking below the structure. Used in combination with a well-developed CSM, this construction technique can be used to reduce the threat of methane accumulation within the structure. In some cases, this reduction of risk could result in minimizing or eliminating the need for other mitigation systems. Note that ground floor components including stairwells, elevators, utility rooms, and utility corridors may still require some form of evaluation and potentially mitigation.

When podium style construction is proposed to address methane, it is considered a methane mitigation system and must meet the requirements specified in this section. EGLE will evaluate these planned ventilation designs on a case-by-case basis to ensure that they provide for long term protectiveness and protection of human health. These reviews will include evaluation of the following:

- the amount of open-air space between the ground and the structure's floor
- the amount of open area for air exchange between the structure's footprint and the surrounding atmosphere
- additional active or passive MMS planned, if any

Aerated sub-flooring systems such as Cupolex® or similar products are not considered podium style construction but rather a component of an active or passive mitigation system.

Typical snow depth should be taken into consideration when evaluating the open-air space between the ground and the structure's floor.

## 6.7 Overall Site Mitigation

Large scale site mitigation measures, such as collection trenches and venting of waste areas, are sometimes needed to adequately address methane for the proposed development. If portions or the entirety of the property were historically used as a mass waste dumping area, direct venting of the defined waste areas is recommended, in addition to building footprint mitigation, if needed.

## 6.8 System Start Up / Commissioning

The commissioning of methane mitigation systems should follow the requirements spelled out in *Volume 5, Response Actions of EGLE's Guidance Document for the Volatilization to the Indoor Air Pathway* that includes the Active or Passive Vapor Mitigation System Table of Contents. Sites with methane present at greater than 50% of the LEL should follow the commissioning requirements for acute scenarios where the commissioning would not be complete for one year.

## 6.9 Submittals to EGLE

Submittals to EGLE should include the following, as appropriate:

- A conceptual site model as described in Attachment 2, including a presentation of:
  - All existing site data showing methane sources, receptors, and migration pathways
  - Description of current and proposed site conditions
  - Defining the extent of waste / MGS materials
  - Cross sections showing pre- and post-development conditions
- An exposure pathway and receptor evaluation for methane, include how changes caused by any new development could impact methane migration and how this will be monitored and addressed
- Mitigation system plans submitted to EGLE for approval should include:
  - Mitigation system design
  - System start-up and commissioning plan including any "As-built" drawings and plans
  - Components of an operation, maintenance, and monitoring plan to ensure that ongoing operation and performance monitoring will occur
  - As described in Section 5.0, mitigation design plans including components of the structure that are to be modified as part of the mitigation must be signed and sealed by a professional engineer licensed in the State of Michigan
- Documentation demonstrating the environmental consultant's or professional engineer's experience in safely redeveloping similar methane projects

Submittals to EGLE should conform with the time, manner, and deliverable requirements of the applicable regulatory program.

# 7.0 Inspection, Maintenance, and Monitoring

Mitigation systems installed to mitigate the threat of methane require inspection, maintenance, and monitoring of the system to ensure the continued effectiveness of the remedy. A written inspection, maintenance, and monitoring plan is recommended for all methane mitigation systems and is required when seeking department approval. Records of installation and repairs over the life of the system should be maintained and must be made available to EGLE upon request.

Although this section primarily covers post-construction inspection, maintenance, and monitoring, it's important to consider methane monitoring during construction to address worker safety. For example, after the concrete slab is poured but before the system is commissioned, indoor air, riser pipes, and other methane monitoring should be conducted at a regular frequency to evaluate potential methane buildup under the slab and/or in the building.

## 7.1 Inspection and Monitoring

Inspections and monitoring are performed to ensure that the system continues to operate as designed. Inspection frequencies for methane mitigation systems typically range from quarterly to annually. It is recommended that new systems are carefully inspected, and performance metrics are monitored at least quarterly for the first year or more of operation, then once a good track record is established at least once per year thereafter. Non-routine inspections should be conducted following certain triggering events such as construction activities, flooding, and if system fail-safe alarms are triggered.

An indoor air methane detection system and other alarms should be inspected, calibrated, and tested by qualified personnel at the frequency recommended by the manufacturer or local code requirements, whichever is more frequent.

In general, any detection of methane in the indoor air should trigger an inspection of the system, as it indicates that the system may not be working. See Table 2 for more information on recommended actions.

## 7.2 Inspection, Operation, Maintenance, and Monitoring Plan

Inspection, operation, maintenance, and monitoring details will vary, depending on the design of the mitigation system and anticipated site use. A plan detailing these activities should be developed to provide guidance to property owners and operators on their obligations for maintaining the system.

General contents of a written inspection, operation, maintenance, and monitoring plan will include but are not limited to:

- Design and construction documentation for the installed system (as-builts), as described in Section 6.0, or reference to where this information may be found
- Schedule and description of the routine and preventative maintenance of the system

- Inspection frequency
- Description of the components of the mitigation system that need to be inspected and maintained including:
  - Inspection checklist
  - Common signs and evidence of deterioration that may be observed
  - List of prohibited activities that would affect the integrity, effectiveness, and operation of the mitigation system or in any way that may render it inoperable, or incapable of functioning as intended
  - List of prohibited building modifications to prevent any decrease in efficiency of the mitigation system or otherwise interfere with the operation of the mitigation system
  - Conditions that require repair or further actions to be taken
- Actions to be taken when conditions are identified that require repair
- Conditions, such as alarms or indoor air levels, that require contacting the fire department and immediate building evacuation
- Provision for maintaining documentation of damage identified and repairs undertaken
- Identification of parties responsible for inspection, maintenance, and repair
- Contact information for the property owner, environmental professional, contractors, or suppliers
- Description of how the plan will continue to be implemented should there be a change in ownership or operation at the property

# 8.0 Institutional Controls and Assurances

Institutional controls are instruments such as deed restrictions, easements, notices, private contracts, and rental or lease agreements that can be used to establish the requirements for the long-term effectiveness and integrity of the remedy and/or limit future exposure to any remaining contamination. These instruments can be used to inform local government units, future property owners, and tenants that contamination is present on the property, restrict activities that may create an exposure risk to methane, or even set inspection schedules and maintenance instructions.

Depending on the type and purpose, an institutional control may include:

- Specific details about the nature and extent of buried waste, methane source, or contamination remaining at the property, including data, maps, and surveys.
- Specific details about the mitigation system, monitoring/alarm system, or other site controls including location, maps, surveys, materials used, inspection schedule, and maintenance requirements.
- Specific activity and use limitations.

- Description of how future lessees, users, and property owners will be notified.
- For all managed, rented, or leased residential and non-residential properties notices should be provided at the time of lease/occupancy and time of renewal (or every 5 years, whichever is sooner), explaining the presence of installed systems, alarms, what the alarms mean, and emergency contacts.

Depending on the property, development, and state and local requirements, an institutional control may exist or be desired for the property. Consult an environmental professional or EGLE for more information on the appropriateness of this tool.

# Attachment 1. Methane Soil Gas Action Levels and Mitigation System Requirements

## Action Levels

| Measure | Action Level 1 – No pressure | Action Level 1 – With pressure | Action Level 2 – No pressure | Action Level 2 – With pressure | Action Level 3 – No pressure | Action Level 3 – With pressure |
|---|---|---|---|---|---|---|
| **Methane Soil Gas Concentration** *(% of the LEL)* | Detected to <25% | Detected to <25% | 25% to <50% | 25% to <50% | =>50% | =>50% |
| **Methane Pressure Differential** (*Inches Water**) | <= 0.25” | > 0.25” | <= 0.25” | > 0.25” | <= 0.25” | > 0.25” |

## Mitigation System Requirements

| Proposed land use | Action Level 1 – No pressure | Action Level 1 – With pressure | Action Level 2 – No pressure | Action Level 2 – With pressure | Action Level 3 – No pressure | Action Level 3 – With pressure |
|---|---|---|---|---|---|---|
| General Residential (Category 1) < 200 foot from MGS material | No Action Required | Monitor to evaluate risk** | Podium | Podium | Podium | Podium |
| General Residential (Category 2), > 200 foot from MGS material | No Action Required | Monitor to evaluate risk** | Podium or Passive MMS | Podium | Podium | Podium |
| Managed Multi-family Residential | No Action Required | Monitor to evaluate risk** | Podium or Passive-Active MMS*** | Podium or Active MMS | Podium or Active MMS | Podium or Active MMS |
| Non-residential | No Action Required | Monitor to evaluate risk** | Podium or Passive-Active MMS*** | Podium or Passive-Active MMS*** | Podium or Passive-Active MMS*** | Podium or Active MMS |

*Inches Water measured relative to indoor or atmospheric pressure

**See Section 4.0 and Attachment 2 for more information.

***Passive-Active MMS = either Passive MMS or Active MMS can be used. Passive MMS should have the ability to be converted to Active MMS, if needed.

Podium = Podium style construction
MGS material = methane generating source material
MMS = Methane Mitigation System
LEL = Lower Explosive Limit

Methane Conversions: 25% of the LEL=1.25% by volume=12,500 ppmv; 50% of the LEL=2.5% by volume=25,000 ppmv

Pressure Conversions: 0.25 inches of water = 62.21 Pascal = 0.009 PSI = 0.0006 Atm. = 0.46 mm of Hg (Torr)

Proposed alternatives and exceptions to Attachment 1 requirements will be evaluated by EGLE on a case-by-case basis.

## Attachment 2. Site Characterization and Developing a Conceptual Site Model for Methane Sites

A conceptual site model (CSM) presents a written and graphical overview of contaminant sources, migration pathways, and potential receptors. Developing a CSM is critical for making risk management decisions and for communication between the party evaluating the site, Michigan Department of Environment, Great Lakes, and Energy (EGLE) staff, stakeholders, and the community.

This attachment provides guidance on the development of CSMs for methane sites and is to be used for evaluating methane intrusion risks for property development projects where methane is or could be a concern. This guide is not intended to be used in developing CSMs to evaluate potential hazards from other gases such as hydrogen sulfide, carbon dioxide, or volatile organic compounds (VOCs). If the presence of other potentially toxic gases is suspected, site assessment activities should be modified accordingly.

A CSM is a living document. It is continually updated as site information is gathered during the assessment process.

Developing a CSM for methane migration to the indoor air pathway includes identifying the locations and types of methane sources, subsurface methane transport mechanisms, and receptors that could be impacted by methane migration, primarily occupants of nearby buildings. The CSM also includes building conditions affecting the rate of methane intrusion into the structure. These conditions typically consist of preferential pathways (e.g., cracks, seams, sumps, utilities) and pressure differentials. A more detailed discussion of pressure differentials is provided in Section 2.3 of this attachment.

A methane intrusion CSM will be similar to other volatilization to indoor air pathway (VIAP) CSMs in many ways, but it will differ to account for the physical and chemical properties and the fate and transport of methane. Modifications will include the following:

- Methane hazards include the potential for explosion and asphyxiation.
- Methane gas migration in the subsurface originating from buried waste sources occurs via a combination of advection and diffusion.
- Methane generated in situ can be accompanied by a positive gas pressure that can result in advective gas flow (pressure driven flow) into structures. Explosive hazards from methane are primarily associated with methane transport by advection.
- Methane transport into a structure through diffusion (concentration gradient flow) is not likely to be significant when compared to advective flow. By contrast, diffusion is typically the major subsurface transport mechanism for VOC vapors from soil and groundwater contamination (e.g. from petroleum sources).
- Like other hydrocarbons, methane will aerobically degrade in the vadose zone. When diffusion is the dominant transport mechanism in the vadose zone, methane will rapidly degrade like petroleum hydrocarbons.

- Evaluation of potential for methane hazards should include consideration for pressure build up in the subsurface in addition to measuring methane concentration.
- Methane generation can vary based on the rate of microbial activity which is affected seasonally by moisture, temperature, frost, and other factors.
- Methane is lighter than air, so there will be potential for some buoyancy-driven migration.
- Methane concentration risk thresholds are in the percent by volume range, compared to VOC risk thresholds, that are in the part per billion by volume range. For example, the lower explosive limit (LEL) of methane is 5% by volume and the upper explosive limit (UEL) is 15% by volume.

Building and refining the CSM is an iterative process that involves utilizing a combination of techniques and tools to understand as much as possible about site conditions. Developing a proper methane CSM can be a lengthy and intensive process. For this reason, development of the CSM should begin during the initial evaluation of a property by researching the site history, potential sources of methane gas generation, and other relevant reconnaissance information. The preliminary CSM is then used to identify data gaps and establish whether additional information needs to be collected from the site.

As additional site-specific information is obtained during site characterization activities and on-site observations, the CSM should be updated to show all known areas of methane generating source (MGS) material and refine what is known about the geology, hydrogeology, fate and transport, preferential pathways, routes of exposure, and potential receptors.

## 1.0 Development And Submittal of Methane CSM

The CSM submittal should be a report that includes the following:

i) Brief site summary
ii) Site description
iii) Source characterization
iv) Methane gas migration
v) Preferential pathways
vi) Receptor discussion
vii) Plan view figures
viii) Cross section figures
ix) Data summary tables

Persons developing and submitting a CSM to EGLE are expected to be knowledgeable in the assessment, mitigation, and engineering practices applicable to the methane sites of concern. Submittals to EGLE must include documentation demonstrating the environmental consultant's or professional engineer's experience in safely redeveloping similar methane projects.

A more detailed discussion of what should be considered or included for items i through ix listed above, is provided in the following Sections 1.1 through 1.6.

### 1.1 Brief Site Summary

The CSM should include a description of the site in general terms, including the address, size, and current land use. The site summary should describe any existing buildings or other infrastructure on the property, as well as any proposed buildings to be constructed on the property. The intended future land use of the site and any proposed land modifications and building construction should be indicated. This section should also summarize the source of methane, migration pathways, and potential receptors discussed in the CSM.

### 1.2 Site Description

The initial CSM is typically developed using existing information. Records including maps, aerial imagery, cross sections, environmental data, and reports should be reviewed to obtain historical site-related information. The site description should include a summary of the historical uses of the property and descriptions of the historical activities, including where these activities occurred on the property. Particular attention should be given to historical waste generation and disposal activities at the site, since methane is produced from the degradation of organic matter under anaerobic subsurface conditions.

Based on the information obtained from the records review, the CSM should identify any major potential sources of methane in the subsurface, which could include solid waste landfills, organic fill material, wetlands, petroleum and gas seeps, natural gas wells and pipelines, sewers, and septic systems. Depending on the source of methane and waste composition, the presence of hydrogen sulfide might need to be assessed as well. Solid waste containing significant quantity of construction and demolition debris including drywall is a typical source of hydrogen sulfide gases in landfills.

Other features of the site that impact source characterization and methane migration potential should be considered and described as part of CSM development and include:

- Identification of key features such as any existing gas collection systems, perimeter gas monitoring probes, methane emission and odor issues for landfill sites, or the lack of methane controls in the case of old dumps.
- Topography, lithology, and hydrogeology that could affect methane migration.
- Nearby existing or planned structures that could be potential receptors.
- The surrounding land use including the locations of structures and other site features.

A thorough understanding of the geological and hydrogeological characteristics of the areas being evaluated, including soil types, permeability, topography, groundwater flow direction, and aquifer properties is important for a complete CSM and should be included in the site description. The physical properties of soil, such as effective porosity, moisture content, and permeability, and methane conductivity/permeability affect the migration of methane in the subsurface and are key components of the CSM. If dissolved-phase plumes are a source of subsurface methane, groundwater flow rates, groundwater flow direction, and depth to groundwater will also affect methane migration.

After existing information records including maps, aerial imagery, cross sections, environmental data, and reports have been reviewed, the CSM should identify data gaps and determine whether additional information needs to be collected from the site.

### 1.3 Source Characterization

The CSM should include a thorough evaluation of the size (footprint and thickness) of waste, age of waste, waste composition, and operational history of the site and/or landfill. If waste is not the source of methane generating material, a description of the source should be clearly described and characterized. Although this document focuses primarily on anthropogenic sources of methane, the concepts contained herein can also be applied to naturally occurring sources of methane.

Other features of the site that impact source characterization and methane migration potential should be considered and described as part of CSM development and include:

- Identification of key features such as any existing gas collection systems, perimeter gas monitoring probes, methane emission and odor issues for landfill sites, or the lack of methane controls in the case of old dumps.
- Topography, lithology, and hydrogeology that could affect methane migration.
- Nearby existing or planned structures that could be potential receptors.

Understanding the extent of buried waste or other methane generating materials is critical to implementing the action levels and risk management decisions discussed in this document. Upon completion of the site characterization, it should be known in three dimensions where MGS material is present and where it is absent (see Section 1.0 of this Methane Guidance document for a definition of MGS material). EGLE should be notified when MGS material cannot be delineated due to access limitations or obligations ending at property boundaries.

The edge of the source area can be estimated between borings if site conditions allow. In general, the greater the risk potential at the site, the greater the precision in data collection is needed. A generalized plan view of expected MGS material characterization and application of the 200’ buffer is provided in the following Figure A2.1.

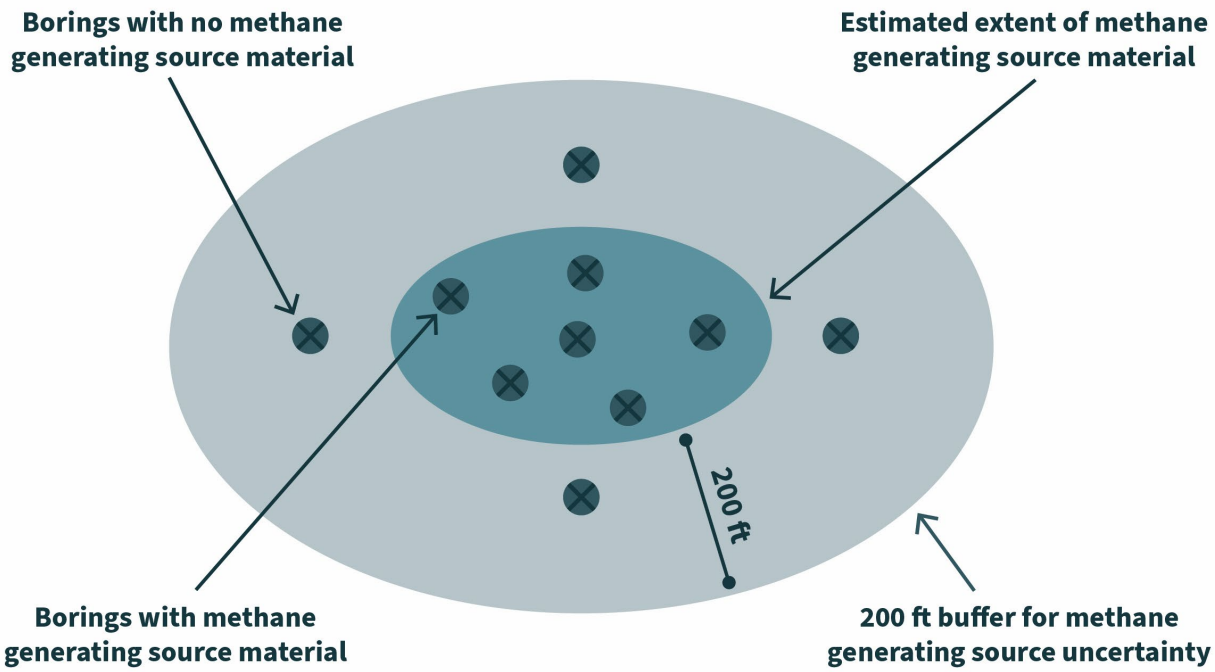


**Figure A2.1**: A generalized plan view of expected methane generating source characterization and application of the 200' buffer for uncertainties.

Determining the maximum distance from an MGS that will require investigation and evaluation, depends on an understanding of the site conditions. In general, a maximum distance of 1,500 feet from known waste can be assumed as a starting point. However, if methane detections in soil gas above 25% of the LEL are found, the soil gas must be delineated to below 25% of the LEL. As a better understanding of the site conditions is obtained, smaller or larger distances may be demonstrated to be appropriate.

Landfill gas, a common methane source, typically contains 45-57% methane, 40-48% carbon dioxide, oxygen, nitrogen, and trace amounts of VOCs. Of particular interest is the ratio of methane, carbon dioxide, and oxygen in soil gas, which can often provide important information regarding the methane source location and methane's fate and transport. The presence of oxygen and carbon dioxide are particularly relevant because oxygen is needed for the aerobic biodegradation of methane to occur, and the presence of carbon dioxide usually indicates biodegradation is occurring. As a result, when monitoring for methane, the measurement of carbon dioxide and oxygen should also be included.

## 1.4 Methane Gas Migration

A CSM should include an evaluation of which exposure pathways are complete or likely to become complete based on the current or intended use of the site. The following are elements of a complete or likely-to-become-complete exposure pathway:

- Methane migration into existing or proposed on-site structures
- Lateral migration of methane to and from adjacent properties
- Effect of site redevelopment on enhancing gas migration laterally and impact on adjacent properties (e.g., redevelopment hardscape such as asphalt parking lots)
- Migration of methane through subsurface preferential pathways, including but not limited to, high permeability zones in the subsurface and utility corridors

Methane intrusion risk should be evaluated in subsurface soil (or waste), soil gas, and groundwater. Understanding the mechanisms of methane migration through these media is essential to a complete CSM. Methane gas migrates via both diffusive and advective flow.

The diffusive flow of methane is driven by concentration gradients, which result in a gradual flow of methane from areas of high concentration to areas of low concentration. The chemical concentration gradient dictates the rate of mass transport, which is typically much slower than mass transport associated with advection. The effective radius of methane diffusion in soil gas is typically limited by aerobic microbial degradation to a scale measured in meters (e.g., DeVaull, 2007). For example, this process is acknowledged by many regulatory bodies (including EGLE) in a lateral inclusion zone used in guidance for the petroleum volatilization-to-indoor-air pathway set to 15 feet, 4.6 meters (EGLE, 2024).

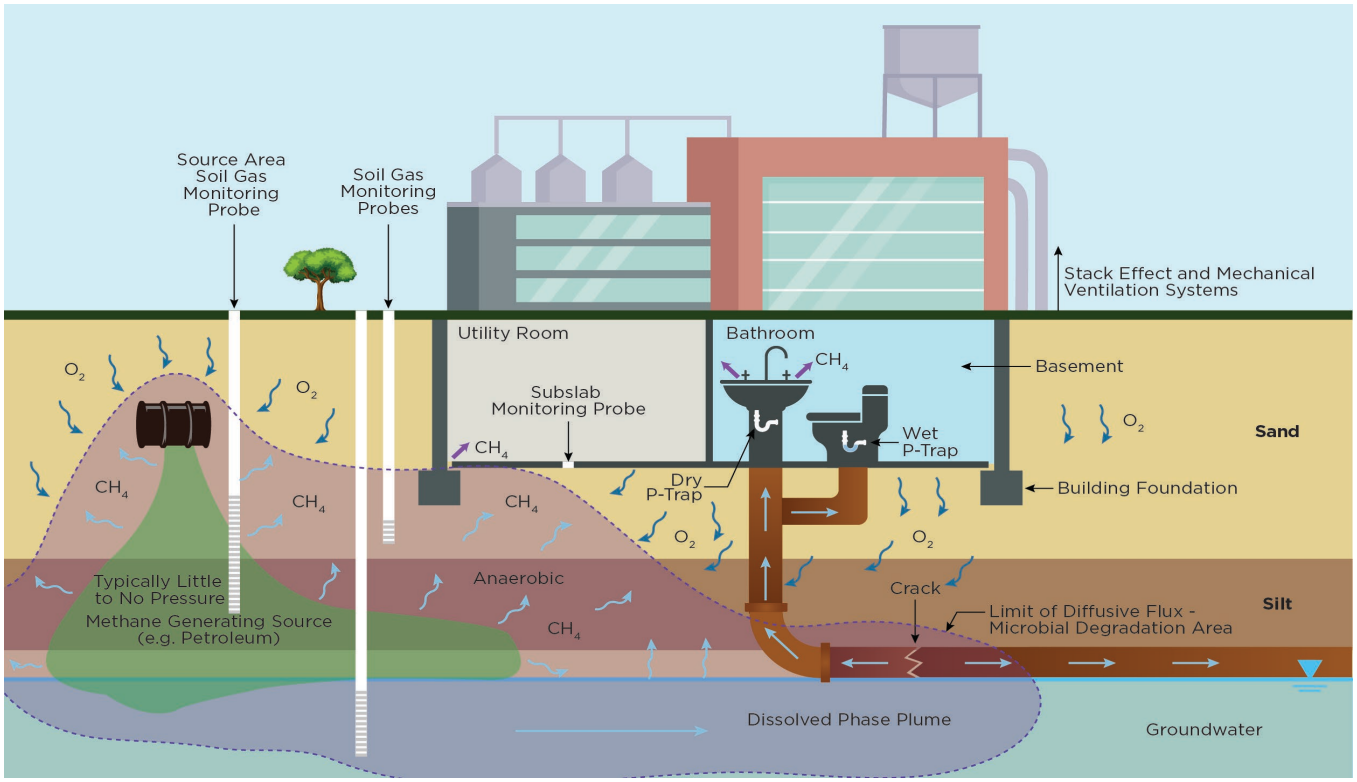


Figure A2.2 Diffusion Dominated Methane Transport

Diffusion will propagate in soils with widely different hydraulic conductivities, crossing silty, sandy or gravelly strata at similar rates (USEPA, 2017). Moisture that occupies pores in very fine soils (smaller than approximately 10-20 microns) will reduce or obstruct mass transport by diffusion. Figure A2.2 provides an example of a CSM where diffusion is the primary driver for methane migration. Under these scenarios, the fate and transport of methane will be similar to petroleum where aerobic degradation significantly limits migration.

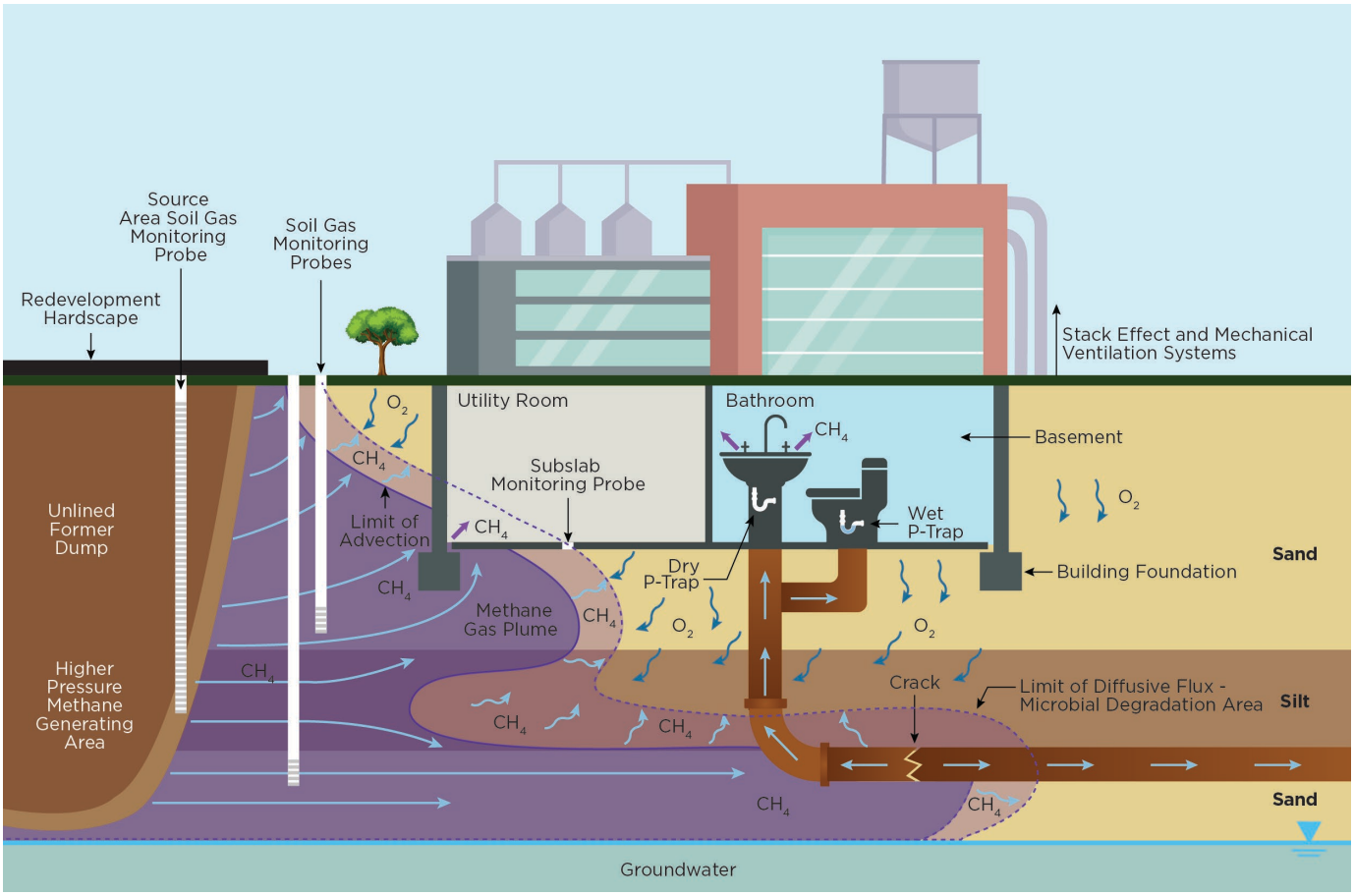


Figure A2.3 Advection Dominated Methane Transport

Advective flow is driven by pressure gradients from areas of higher pressure to lower pressure through zones of higher pneumatic conductivity and is the primary mechanism for significant methane migration in unsaturated soil away from a MGS to receptors. Methane advection can be limited by fine-grained soil but not by aerobic biodegradation. Figure A2.3 provides a schematic illustrating the concepts of advection dominated transport.

When diffusion is the primary means of methane transport, methane will behave similar to petroleum, with aerobic degradation significantly limiting migration.

Advective flow is typically the primary mechanism for significant methane migration and is not limited by aerobic degradation.

### 1.5 Preferential Pathways

Methane migration can be affected by preferential pathways such as higher-permeability layers in the vadose zone, utility corridors (often backfilled with coarse aggregate materials), cracks in building foundations and slabs, the head space inside utilities, elevator pits, and basement sumps. The potential for methane to migrate into the existing on-site, proposed, or nearby structures through preferential pathways should be evaluated. This evaluation should also consider factors such as building construction, foundation type, foundation/slab condition, ventilation, and heating and cooling. Crawl spaces and other confined spaces where methane can accumulate at high concentrations should also be considered in the CSM.

### 1.6 Receptor Discussion

The primary receptors of interest for methane intrusion risk evaluation are the occupants of any buildings present within 200 feet from the edge of the MGS material. The action levels for methane mitigation are dependent on the planned land use of the development and differ between General Residential, Managed Multi-family Residential, and Non-residential uses (see Attachment 1).

The evaluation of methane intrusion risk to potential receptors requires consideration of both concentration and pressure. The maximum observed pressure and methane concentration should be compared to the action levels in Attachment 1 to evaluate whether the intended land use is supported by this guidance and to establish what monitoring or mitigation measures are required for the planned development.

A methane concentration of 10% of the LEL in indoor air within the building calls for an immediate response, and a notification to the local fire and health departments. Occupancy of the building will not be recommended until the concentration of methane is reduced to below 10% LEL.

Development of the CSM should also consider the impact of subsurface methane at the site on adjacent properties during redevelopment. This may reveal the need to monitor methane concentration and pressure at the development's perimeter, which can change with the installation of hardscape (e.g., asphalt parking lots acting as caps). The evaluation can be accomplished by installing monitoring points around the outside of the development and monitoring them pre- and post-development for changes and to ensure that methane concentrations stay below 25% of the LEL.

### 1.7 Figures and Tables

CSM submittals should include figures, summary tables, and other relevant exhibits communicating the available data and site information in a way that is easy to understand.

Both plan view figures and cross section drawings prepared for the CSM should identify methane sources, site geology, depth to groundwater, preferential pathways, and receptor locations as applicable. Figures included with the CSM should show the spatial relationship of methane sources, sample locations, and receptors. A "not to scale" diagrammatic drawing,

similar to that shown in Figures A2.2 and A2.3, may be useful as part of the CSM as a means to convey information on potential methane gas hazards at the site.

The tables should summarize all available site data in an easy-to-understand manner. This should ideally include items such as differential pressures, methane concentrations (groundwater, soil gas, and indoor air), concentrations of carbon dioxide and oxygen, and when appropriate, concentrations of hydrogen sulfide.

Figures, cross sections, and tables should be updated as more information becomes available through the investigation activities described in this document.

## 2.0 Detailed Sampling Program Design

A sampling program should evaluate methane and its transport in soil gas, groundwater, and indoor air, if appropriate. The program should be designed to measure the concentration, extent, and pressure of methane in soil gas at various depths and distances from the methane sources. These values can be used to evaluate the potential for a methane hazard to exist at a redevelopment site.

The following sections provide guidance on soil gas measurements, probe construction, spacing, and depths within the source area, between the source area and buildings, and within building footprints, as well as groundwater sampling and building-specific investigations.

### 2.1 Monitoring Frequency

Environmental factors such as changes in atmospheric pressure and the presence of frost can influence the rate of subsurface methane migration and pressure. Temperature can also influence the rate of methane generation in the subsurface. Monitoring should include sufficient events to evaluate fluctuations of methane concentration and pressure in the subsurface over time and during different seasonal conditions while recording atmospheric pressure and air temperature during each event. EGLE recommends conducting, at a minimum, one year of quarterly monitoring, including at least one event conducted during periods of frost.

### 2.2 Soil Gas Monitoring

Soil gas monitoring is a critical tool in the characterization and evaluation of methane. Soil gas monitoring within the waste boundary or MGS may represent the worst-case location in terms of methane concentration and pressure. This monitoring is used along with boring logs to determine the extent of waste fill and to guide design approaches for redevelopment projects. Monitoring probes in the waste should be screened through most of the waste column above the water table to maximize detection, with consideration of proximity to the surface to avoid atmospheric air intrusion. Soil gas probes should be installed to the depth of the waste or to immediately above the water table (if the bottom of the waste is deeper than the water table).

Soil gas probes for methane monitoring outside of the source area should be constructed similarly to soil gas probes for evaluating the VIAP (Appendix F.1 of EGLE, 2013).

After construction, all soil gas probes should be fitted with a valve to facilitate differential pressure monitoring. Soil gas sample points must be allowed to stabilize for a period of at least 48 hours or several days (typically not more than seven days) prior to differential pressure monitoring and sampling. Alternate, defensible approaches may also be proposed.

## 2.3 Soil Gas Probe Placement

### *2.3.1 Soil Gas Probe Spacing*

Generally, one soil gas probe should be installed for every 10,000 square feet of site area within 200 feet of the edge of the MGS material, with a minimum of two soil gas probes installed at the site (NCDEQ 2020; Colorado Department of Public Health and Environment [CDPHE] 2023; Los Angeles Department of Building and Safety [LADBS] 2023). When waste material is deeper than four feet below grade, nested probes can be installed at a space of one per 20,000 square feet of site area.

Alternatively, when the methane source is confirmed to be off-site (migrating onto the subject property), methane and fixed gas measurements can be made along the site boundary closest to the source at a minimum rate of one measurement per 100 lineal feet (CDPHE 2023; LADBS 2023). If existing buildings are present on-site, soil gas probes or sub-slab probes should be installed between the building and the MGS area.

### *2.3.2 Soil Gas Probe Depths*

When the depth to waste material is greater than four feet below grade, the evaluation of the potential for methane migration should include the use of multi-level (or nested) probes. As the depth to the water table surface allows, each soil gas probe location should consist of three probes installed at approximate sampling depths of five feet, 10 feet, and 20 feet below the lowest building slab or footing of the building, or at depths appropriate with respect to the MGS material, permeable geological layers, and other potential pathways. All soil gas probes should be installed at least 12 inches above the ground water table.

When the depth to waste material is less than four feet below grade and no building is present, soil gas probes should be installed into the waste material at a depth of at least five feet below ground surface to limit interference from ambient air on field readings (ASTM 2023; North Carolina Department of Environmental Quality [NCDEQ] 2020). If a building is currently present, sub-slab soil gas samples should be collected instead of soil gas probes at depths into the waste.

If groundwater at the site is less than five feet below ground surface, installing soil gas probes prior to development may not be representative of future use. In this circumstance, considerations for atmospheric dilution or differential pressure changes should be planned and accounted for prior to data collection. The uncertainty introduced from potential atmospheric dilution or changes in pressure differential associated with development, will be reduced with post-redevelopment data collection.

It is important to recognize that shallow soil gas evaluations may not represent future concentrations and pressures that may arise from redevelopment with hardscape. In this case, it is recommended to continue evaluations after redevelopment and have contingency plans ready to implement if elevated subsurface methane concentrations and/or pressure are observed after construction. If it is desired to utilize pre-development shallow soil gas data as a line of evidence for current conditions, the practitioner should understand the uncertainty with the data and try to install them as deep as possible, while ensuring that they will remain above the water table and capillary rise.

### 2.4 Differential Pressure Monitoring and Field Screening

Differential pressure is a measurement of the difference between the soil gas pressure at some depth in the vadose zone and another point in the vadose zone, indoor, or outdoor air pressure. If a building is present, the differential pressure between the sub-slab and the building will be critical in determining the migration of methane into the structure. Differential pressure measurements are useful to support the evaluation for potential advective transport of methane.

Differential pressure can vary over time based on barometric pressure, wind speed, or overlying building conditions (e.g., HVAC usage). This variability should be accounted for by documenting weather and building conditions over multiple seasonal sampling events, as described in Section 2.1. Ideally, each seasonal pressure measurement would be made over a period of days or weeks during various conditions. When considering potential sampling frequencies at a site, the CSM should be considered to determine what is needed to accurately reflect the variability of this parameter. The precision and amount of data required should be based on the risk at the site.

Differential pressure readings should be collected prior to methane and other gas readings, as purging soil gas from the probe can change the differential pressure from steady-state conditions.

Differential pressure can be measured with a digital micromanometer or analog devices such as Magnehelic gauges in various ranges (e.g., 0 to 0.25, 0 to 2, 0 to 15 inches of water) that will provide flexibility and precision until site conditions are understood. Methane field screening is typically done via dual beam infrared absorption using a landfill gas meter (e.g., Landtec GEM 5000, or equivalent) and should include documentation of methane, carbon dioxide, oxygen, and potentially hydrogen sulfide concentrations.

It should be noted that infrared landfill gas meters can potentially bias methane results high by reporting other alkanes present in soil gas as methane. Laboratory analysis of soil gas for methane can provide lower and more accurate readings. If collecting analytical samples, check labeling requirements, shipping regulations, and carrier policies before shipment.

## 2.5 Groundwater Monitoring

Dissolved phase plumes of methane could be present in groundwater. Temporary or permanent monitoring wells should be used to characterize methane concentrations in groundwater. Groundwater samples should be collected using EGLE accepted procedures with techniques that minimize the loss of methane.

The location and number of monitoring wells required will depend on site-specific conditions. However, a minimum of one monitoring well upgradient, downgradient, cross-gradient, and near the known or suspected methane source is recommended. Additional monitoring wells could be required based on the location of receptors or preferential pathways relative to the release.

When applicable, include the following data objectives into a methane groundwater investigation:

- Identify and characterize the MGS material contributing to methane in groundwater
- Evaluate the extent of methane in groundwater
- Evaluate the direction(s) of groundwater flow
- Evaluate the potential for continued methane migration
- Evaluate the potential variability and fluctuation of ground water elevation

## 2.6 Indoor Air Monitoring in Existing Buildings

Soil gas advection into buildings occurs through cracks, joints, utility penetrations, and other openings. Indoor air methane investigations should be focused on areas where these openings are present or suspected. Consider screening indoor air for methane near the source area, potential gas entry points, and enclosed spaces. Indoor air methane concentrations can be collected via a calibrated field instrument (e.g., multi-gas meter or equivalent device). Additionally, the air exchange rates in the building and in smaller spaces inside the building should be considered when developing the CSM, as these can have an effect on the accumulation of methane in an enclosed space.

Any indoor air screening or sampling should be accompanied by a building survey, including documentation of potential interior sources of methane (e.g., gas ovens, ranges, dryers, water heaters, fireplaces).

## Attachment 3. Acknowledgements And References

The following documents were cited and/or utilized as reference materials in the development of the Guidance Document "Development on or Near Methane Generating Sources" and the accompanying attachment "Site Characterization and Developing a Conceptual Site Model for Methane Sites."


- ASTM International. 2023. "Designation E2993—23 Standard Guide for Evaluating Potential Hazard in Buildings as a Result of Methane in the Vadose Zone." November 2023.
- CDPHE. 2023. "Colorado Methane Intrusion Guidance." Colorado Department of Public Health and Environment. July 2023.
- DeVaull, George E., 2007. "Indoor vapor intrusion with oxygen-limited biodegradation for a subsurface gasoline source." Environmental science & technology 41.9: 3241-3248.
- EGLE, 2013. "Guidance Document for the Vapor Intrusion Pathway." Michigan Department of Environment, Great Lakes, and Energy Remediation and Redevelopment Division. May 2013.
- EGLE, 2024. Guidance Document for the Volatilization to the Indoor Air Pathway (VIAP). Approach for Petroleum VIAP, Volume 4: Investigative Approach for Petroleum VIAP. June 2024.
- Eklund, Bart. 2010. "Proposed Regulatory Framework for Evaluating the Methane Hazard due to Vapor Intrusion." Vapor Intrusion Specialty Conference, URS Corporation. https://www.provectusenvironmental.com/marketing/tech_docs/Proposed_Regulatory_Framework_for_Evaluating_Methane_Hazard_due_to_Vapor_Intrusion-Eklund.pdf
- ITRC. 2020. "Conceptual Site Models for Vapor Intrusion Mitigation." Interstate Technology Regulatory Council. December.
- LADBS. 2023. "Site Testing Standards for Methane." Los Angeles Department of Building and Safety. January 2023.
- MPCA. 2024. "Best Management Practices for Development on or Near Former Dumps" Minnesota Pollution Control Agency. April 2024.
- MPCA. 2024. "Remediation Division Methane Guidance" Minnesota Pollution Control Agency. May 2024.
- NCDEQ. 2020. "Methane Assessment Protocol." Brownfields Program, North Carolina Department of Environmental Quality. July 2020, revised December 2020.
- NCDEQ. 2020. "Threshold Criteria for Methane Site Development." Brownfields Program, North Carolina Department of Environmental Quality. December 2020.
- NCDEQ. 2020. "Minimum Requirements for Townhome Developments." Brownfields Program, North Carolina Department of Environmental Quality. May 2020.

- [U.S. EPA] United States Environmental Protection Agency, 2017. “Documentation for EPA’s Implementation of the Johnson and Ettinger Model to Evaluate Site Specific Vapor Intrusion into Buildings.” Version 6.0, Office of Superfund Remediation and Technology Innovation, William Jefferson Clinton Building, 5202G, 1200 Pennsylvania Avenue, NW, Washington, D.C. 20460, Revised September 2017
- [U.S. EPA] United States Environmental Protection Agency, 2024. “Climate Change Indicators: Atmospheric Concentrations of Greenhouse Gases.” https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases
- WDNR. 2002. “Development at Historic Fill Sites and Licensed Landfills: Considerations and Potential Problems.” Wisconsin Department of Natural Resources. April 2002.


Special thanks to Geosyntec for their assistance in the development of this document and the accompanying figures.