Department of Toxic Substances Control

Terry Tamminen
Agency Secretary
Cal/EPA

1011 North Grandview Avenue
Glendale, California 91201

Arnold Schwarzenegger
Governor

ADVISORY ON METHANE ASSESSMENT AND COMMON REMEDIES AT SCHOOL SITES

SCHOOL PROPERTY EVALUATION AND CLEANUP DIVISION DEPARTMENT OF TOXIC SUBSTANCES CONTROL

This document is released as an advisory subject to review and revision as necessary. The information in this advisory should not be considered enforceable or regulatory in nature (i.e., this advisory does not have the force or effect of law). Mention of trade names or commercial products does not constitute DTSC's endorsement or recommendation.

Advisory Contents

1.0 INTRODUCTION

This advisory provides guidance on investigations and common remedies for school sites where methane gas is the only chemical of concern present in subsurface soils. This advisory may be used to supplement remedies for sites with multiple contaminants in soil gas, e.g., hydrogen sulfide or volatile organic compounds (VOCs), in addition to methane. However, care should be taken to address the risks associated with the other contaminants. For example, passively venting methane on a site may be appropriate, but the presence of hydrogen sulfide commingled with methane may make passive venting unacceptable.

Methane is considered a naturally-occurring hazardous material under Education Code section 17210.1. If a response action is necessary to address the presence of methane, a Removal Action Workplan (RAW) or Remedial Action Plan should be submitted for DTSC review and approval pursuant to Health and Safety Code section 25356.1. Most response actions at school sites will be removal actions, pursuant to a RAW. Whenever a removal action has an impact on the design of a school facility, DTSC will notify the Division of the State Architect (DSA) and specify conditions for the RAW to be properly implemented during the school construction pursuant to Education Code section 17213.2, subsection (g).

This advisory provides a consistent statewide approach in addressing methane-only concerns. However, due to the variability of local regulations and site-specific conditions, compliance with all applicable or relevant and appropriate requirements (ARARs), e.g., applicable federal, state or local laws, regulations, ordinances or building codes for methane is required. In addition, compliance with the requirements of utility (e.g., power) companies regarding gas mitigation measures for vaults, transformers, electrical conduits, or other improvements is needed.

2.0 METHANE HAZARDS AND RECOMMENDED ACTION LEVELS

Methane is lighter than air, colorless, odorless, non-carcinogenic, and flammable. When methane is mixed with other gases, e.g., carbon dioxide, hydrocarbons, the methane gas mixtures typically have densities comparable to, or less than, air. Methane occurs as natural gas in coal mines, oil and gas fields, and other geological formations; as a byproduct of petroleum refining; and as a product of decomposition of organic matter in natural settings (e.g., wetlands), and man-made settings (e.g., landfills, engineered fill, hydrocarbon waste, food processing facilities, sewer lines, septic systems, dairies and concentrated animal feedlots).

There are two primary mechanisms by which methane is produced. Thermogenic methane is generated at depth under elevated pressure during and following the formation of petroleum (e.g., in oil fields). Biogenic methane is formed at relatively shallow depths by the bacteriological decomposition of organic matter in the soil (e.g., in landfills). Biogenic methane is rarely found under a pressure in excess of a few inches of water.

The primary mechanisms for methane migration in the subsurface are pressure driven flow and diffusion. Methane will migrate from areas where it is present at higher pressures or concentrations to areas where it is present at lower pressures or concentrations. Since methane is lighter than air, it has a tendency to rise from depth to the ground surface where it dissipates into the atmosphere. Where a relatively impermeable barrier, e.g., a concrete slab, is present at the ground surface, the potential exists for methane to accumulate beneath that barrier.

2.1 Methane Hazards

Methane is an asphyxiant and is combustible and potentially explosive when it is present at concentrations in excess of 53,000 parts per million by volume (ppmv) in the presence of oxygen. This concentration is referred to as the Lower Explosive Limit (LEL). In order to provide some margin of safety, a concentration of approximately ten percent (10%) of the LEL or 5,000 ppmv is commonly utilized as an "action level" above which mitigative measures are recommended. Where it is present at concentrations in excess of 5,000 ppmv, it is often conservatively presumed that methane may infiltrate through flooring material or cracks, accumulate under footings and in enclosed spaces (e.g., small rooms, vaults, wall spaces), and then cause a fire or explosion when an ignition source (e.g., pilot flame, electrical spark, cigarette) is present.

For the purposes of this advisory, a methane hazard is defined as an accumulation, or the potential accumulation, of methane in the subsurface immediately beneath the footprint of an existing or proposed school building, including associated improvements, at concentrations in excess of 5,000 ppmv.

2.2 Recommended Action Levels for Methane Concerns

A. The following screening levels may be used as a guide for further action on school sites where methane is the only chemical of concern, present in subsurface soil. These levels are, in part, based upon a survey of local regulations and ordinances:

   1. Methane detection of 1,000 ppmv (a cautionary value) – Further investigation is recommended to determine the extent of methane in subsurface soil, potential source, and/or soil lithology.

   2. Methane detection of 5,000 ppmv (10% of the LEL) – Further response action (e.g., periodic monitoring, removal action) may be needed.

   3. Methane pressure of 0.1 pounds per square inch (psi), 2.8 inches of water, or 0.2 inches of mercury – Further investigation is recommended to determine the extent of methane in subsurface soil, potential source, and/or soil lithology.

4. Methane pressure of 0.5 psi, 13.9 inches of water, or 1 inch of mercury – Further response action (e.g., periodic monitoring, removal action) may be needed.

B. While specific remedies are not discussed herein for sites where subsurface methane levels fall between 1,000 and 5,000 ppmv or methane pressures are between 0.1 to 0.5 psi, a combination of enhanced interior ventilation systems (e.g., blower with a larger capacity), conduit seals, utility trench dams, and other easily installed mitigative improvements should be considered for structures on these sites based on site-specific conditions.

3.0 METHANE ASSESSMENTS

A potential problematic accumulation of methane within a structure may be caused by the following conditions:

- Methane concentration in excess of 53,000 ppmv and sufficient volume to produce elevated gas levels on the interior of the structure; or
- An elevated gas pressure (e.g., 0.1 psi) to induce flow into the building.

Although methane will accumulate under appropriate conditions, methane typically does not accumulate to a concentration that exceeds the maximum concentration of the source. Accordingly, the source(s) of methane at a site should be determined. The maximum concentration of methane associated with each source may need to be identified through the installation and monitoring of subsurface gas probes. It should be recognized that multiple sources may be present. In addition, any subsurface methane investigation needs to screen for the possible presence of large zones of methane accumulation, or smaller zones where gas is present at elevated pressures.

Any methane investigation should be conducted to determine the nature and extent of methane concerns, consistent with the current version of DTSC's "Advisory – Active Soil Gas Investigations, dated January 28, 2003 (ASGI)." Rationale should be provided for the proposed sample number, locations, depths, and analyses.

3.1 Methane Investigation Strategy

A methane investigation strategy generally includes the following:

A. Methane sampling depths generally include five (5) and 15 feet, and may extend to 40 feet, below ground surface (bgs), as appropriate. Deeper probes may be necessary, depending on site conditions.

B. Methane sampling spacing generally requires a 100-foot grid system to screen the site. In potential source areas or areas with known high methane concern (e.g., settling pond areas, manure pile areas), a higher density sampling should be conducted. Step-out samples and, if appropriate, off-site samples should be collected up to 200 feet away from a proposed or existing structure.

C. Consideration should be given to field conditions (e.g., irrigation, fine grained sediments), weather conditions (e.g., rising barometric pressure, high wind speeds of 25 miles per hour or more, significant rainfall events of ½ inch or greater) which may affect collection of methane data.

D. The detection limit for methane analysis should not exceed 500 ppmv (see Sections 8.5.D and F).

E. The use of a properly calibrated hand-held instrument for methane monitoring is acceptable. When a hand-held instrument is used to measure methane concentrations, DTSC recommends at least 10 percent of all positive methane samples (with methane concentrations of 5,000 ppmv or greater), rounded to the nearest whole number, be confirmed by another hand-held instrument (different unit or different brand) or by a gas chromatograph method (on-site or off-site).

F. At sites where methane is detected at a level of 5,000 ppmv or above, fixed gas (oxygen and carbon dioxide) data and barometric pressures should be obtained.

G. At sites where the presence of hydrogen sulfide or volatile organic compounds (VOCs) is suspected (e.g., oil fields, landfills), hydrogen sulfide or VOC data should also be obtained.

H. Accurate molar ratios of alkanes to alkenes, presence or absence of carbon dioxide, presence or absence of hydrogen sulfide, presence of ethanes, propanes and butanes, and isotopic abundance analyses ($^{13}C/^{12}C$ and D/H ratios) can be used to differentiate methane generation sources (e.g., thermogenic, biogenic origins).

I. Soil parameters (e.g., soil grain size, porosity, moisture, bulk density, total organic carbon content, vapor permeability, soil redox potential) may be required to fulfill design requirements of the mitigation measures (see Sections 3.2, 5.3.A.2 and 5.4.A.1).

3.2 Evaluation of Fill Materials

When import soils are necessary, the current version of DTSC's "Information Advisory – Clean Imported Fill Material" should be followed to evaluate for the presence of contaminants prior to use as fill material. The fill material should also be evaluated for the presence of elevated total organic carbon (TOC). When the fill depth is anticipated to be 10 feet or thicker, any import fill source with TOC of 0.5% or above should be rejected or a methane evaluation should be conducted at least 30 days after fill placement and compaction.

All available data regarding fill materials emplaced onsite should be evaluated for potential presence of contaminants. When fill depth exceeds 10 feet, the soil should also be evaluated for the potential presence of methane or methane generation. If TOC or methane data regarding the fill material is not available, or if methane concern can not be ruled out for the fill material with proper justifications, it is advisable to collect and analyze two (2) soil samples (at 5-foot bgs and the inter-phase between native soil and fill material) for TOC, or two (2) soil gas samples (at 5- and 15-foot bgs) for methane, for each 5,000 square feet of proposed building footprint. TOC data may be obtained during a geological and soil engineering study required by Education Code section 17212.5, or during a Phase I Environmental Site Assessment required by Education Code section 17213.1. See Section 5.2.A.2 for more information.

4.0 METHANE RESPONSE ACTION OBJECTIVES

Response Action Objectives (RAOs) should be protective of human health, the environment and public safety. The primary RAOs for a site with methane as the only chemical of concern may include the following:

- Reduce or monitor the potential for methane accumulation underneath proposed and/or current structures, not necessarily to remove the source as for normal response actions;
- Remove or treat impacted soils that contain methane at a concentration of 5,000 ppmv or above;
- Minimize the potential for migration of methane from the site to other areas; and/or
- Obtain a certification by DTSC as specified in Section 7.0 for the site, after completion of the response action and prior to any school occupancy.

Additional RAOs should be provided based on site-specific conditions.

5.0 COMMON REMEDIES FOR METHANE SITES

Any potential changes in site conditions that could have a significant impact on the subsurface methane concentration should be discussed and evaluated. Those areas for which the potential exists for methane to accumulate to the LEL immediately beneath a school building or associated improvement should require mitigation (see Section 2.2.A).

Most response action activities at school sites have historically been removal actions, which require a RAW. Based on historical patterns of remedy selection for sites where methane is the only chemical of concern and DTSC's scientific and engineering evaluation, DTSC has considered four (4) remedies to be common remedies for subsurface methane. They were selected based on an evaluation of three technology evaluation criteria: effectiveness, implement ability, and cost. These remedies may be used for methane-only sites, based on site-specific conditions. However, other remedies may be proposed for DTSC review and approval. Based on site-specific conditions, additional methane detection or reduction measures (e.g., a combination of gas monitoring, gas control, sensors, alarms, conduit seals, utility trench dams, enhanced ventilation systems) may also be needed.

When the approved remedy for a site requires long-term Operation and Maintenance (O&M) activities, DTSC will enter into an O&M Agreement with the school district prior to site certification. Once signed, this enforceable document requires the school district to implement the required O&M activities in accordance with an approved O&M Plan under DTSC oversight (see Section 7.0).

All design, construction, or O&M activities associated with methane remedies should be conducted or supervised by a methane engineer. For the purposes of this advisory, the methane engineer is a professional engineer (e.g., Civil or Geotechnical Engineer) licensed in California and experienced in methane investigation and mitigation for protection of structures.

The following four (4) common remedies have been identified:

- Excavation of Shallow or Limited Methane Sources
- Methane Monitoring Program
- Methane Collection and Passive Vent System (Without Membrane)
- Methane Collection, Membrane and Passive Vent System

5.1 Excavation of Shallow or Limited Methane Sources

Example: Soil excavation at a site where a shallow (e.g., less than 10 feet in depth) or limited (e.g., less than 5,000 cubic feet in volume) methane source is identified and excavation is economically and practically feasible.

This remedy is the excavation and disposal of organic-rich soils where methane gas is generated in excess of 5,000 ppmv. This remedy may be proposed for shallow or limited methane sources where a cleanup below the action level specified in Section 2.0 is economically and practically feasible. The purpose of this remedy is to remove the organic matter which provides a food source for the bacteria that produce the methane. To be an acceptable remedy, it should provide a permanent solution to reduce subsurface methane levels and any associated threat to human health and safety.

All excavations should be backfilled with clean fill material (see Section 3.2). Consideration should be given to the presence of additional sources and onsite migration of methane from offsite sources when considering this alternative.

5.2 Methane Monitoring Program

Example: Methane monitoring at a joint-use city park adjacent to a school

This monitoring program involves the installation and monitoring of gas probes which provide a means of identifying the extent, distribution, concentration, and pressure of combustible gas in the subsurface. A methane monitoring program may be acceptable in place of other mitigative actions for low risk areas of concern (e.g., open space areas where the potential for methane accumulation to problematic levels is shown to be low).

A. Monitoring Program Considerations

Considerations for this monitoring program include:

1. If only a monitoring program is proposed as a precautionary measure for a school site (e.g., for open space areas), DTSC may recommend the school district enter into an O&M agreement with DTSC. In this case, a RAW may not be required;

2. Open space areas of concern will be subject to review and/or approval by DTSC whenever there is a site condition change (e.g., grading or addition/modification of a structure). Aerobic conditions in the subsurface soil will cause methane to be consumed or degraded by methanotropic bacteria. Elevated levels of carbon dioxide in the subsurface soil are typically indicative of the ongoing biodegradation of organic matter in an aerobic environment. This can make it difficult to estimate the methane concentration after the site is developed. The absence of methane does not mean that elevated levels of methane will not occur in the future. Because the distribution of the organic material, oxygen and soil moisture may be altered by grading activities, school sites that have, or may potentially have, methane gas associated with biodegradation of organic material entrained within the soil, may require reassessment of soil and soil gas conditions after completion of the mass (rough site) grading activities. The placement of fill containing elevated levels of organic matter can result in higher and/or more extensive post-grading methane levels; and

3. Buildings, paved surfaces, and irrigated fields can affect air diffusion and barometric pumping through the soil. The improvements also act to block methane venting. Oftentimes the building becomes the easiest vent point because the vent trenches and pipes installed below the building provide a relief point. Therefore, the installation of hard-scape covering 5,000 square feet (ft^2) or more within fifteen (15) feet of any structure of concern may require the installation of methane mitigation improvements (e.g., methane collection and passive venting systems), in addition to a methane monitoring program, to protect the structure.

B. Design of Methane Monitoring Program

When a methane monitoring program is proposed, a detailed outline for the program should be prepared and submitted to DTSC for review and approval. The outline should specify monitoring procedures, locations, frequencies, and equipment. A contingency plan should also be provided along with a description of the conditions (e.g., action levels) at which the contingency plan would be implemented. See Sections 8.2 and 8.5 for recommendation on O&M frequency and contingency plan, respectively. The design of the methane monitoring program should incorporate the following considerations:

1. Monitoring of subsurface gas probes should include the measurement of the concentrations of methane, oxygen, and carbon dioxide as well as the measurement of the gas pressure within the probe and the barometric pressure at the time of the monitoring. For oil fields, landfills, or other sites where the presence of hydrogen sulfide is suspected, analysis of hydrogen sulfide should also be included;

2. Periodic monitoring of combustible gas levels along the ground surface in open areas, within crawl spaces beneath a structure, and/or inside a building may also be included as part of this program; and

3. All gas probes should be properly secured, capped and completed to prevent infiltration of water and ambient air into the subsurface and to prevent accidental damage or vandalism of the probes. Replacement or repair may be needed due to the conditions of the gas probes or disturbance due to construction activities. For probe surface completions, the following components should be installed:

    a. Surface seal;

    b. Utility vault or meter box with ventilation holes and lock; and

    c. Gas-tight valve or fitting for capping the sampling tube.

C. Operation and Maintenance Requirements

If an O&M agreement is developed, typical O&M activities that may be required under this agreement include the following:

1. Routine inspection of the area of concern (including multi-stage gas probes) to ensure there are no signs of degradation of the gas probes and no significant site condition changes; and

2. Routine monitoring of gas probes and surface sweeps with a Flame Ionization Detector to determine if significant changes in subsurface gas concentrations or pressure have occurred.

See Section 8.2 for recommendation on O&M frequency.

5.3 Methane Collection and Passive Vent Systems (Without Membrane)

Example: Retrofit existing classroom buildings with methane mitigation.

This mitigative approach involves the installation of a sub-slab collection and passive vent system to retrofit existing structures where installation of a membrane system is not feasible.

A. Design Requirements

The following recommendations should be incorporated in the design of a methane collection and passive vent system:

1. Methane Monitoring Program

   All design recommendations for a methane monitoring program specified in Section 5.2 are generally applicable.

2. Collection Pipe Spacing and Diameter

   Soil properties (e.g., soil gas transmissivity and diffusivity coefficients) should be considered in the spacing of the sub-slab collection piping system. At a minimum, a methane collection pipe system should be placed such that all points immediately beneath the slab are located within 20 feet of a collection pipe. The subsurface gas collection pipes should be perforated and two (2) inches in diameter (or greater). Flat drains may be used as an alternative to round collection pipes.

3. Collection Pipe Layout

   The gas collection piping should be installed within horizontal, or near horizontal trenches excavated beneath the building which is to be protected. The collection piping should extend the full width of the building and be located no more than five (5) feet beneath the ground surface. The piping system should be connected using threads, not solvent-welded. The need for drainage or de-watering improvements to prevent flooding of any portion of the collection/vent piping should be evaluated and suitable improvements should be installed, as necessary, to insure the proper operation of the collection pipe system.

4. Vent Riser Design

The underground gas collection pipes should be connected to solid vent risers that extend above the building. The vent risers should be equipped with a sampling port and fitted with a non-restricting rain guard to prevent precipitation and debris from entering the piping system. Vent risers should be properly secured (e.g., enclosed within wall cavities or pipe chases) to protect them from damage. A minimum of two (2) vertical vent risers (equivalent two 2-inch diameter) for the first 10,000 ft^2 of building foot print area and one additional vertical vent riser for each additional 10,000 ft^2 of building foot print should be provided. Vent risers should terminate at least two (2) feet above the non-combustible roof of the structure, at least 10 feet away from any window or air intake into the building, and at different elevations to promote methane ventilation.

5. Vent Riser Diameter

Each vent riser piping should consist of two (2)-inch diameter cast iron pipes or equivalent. The size of the vent risers may be reduced to 1-1/2 inches where necessary for structural reasons – provided additional vent risers are installed to provide a flow capacity equivalent to the appropriate number of 2-inch diameter vent risers. Table 1, included as Attachment A, shows the relative flow capacity of different size vent risers.

6. Utility Trench

Utility trench dams should be installed as a precautionary measure to reduce the potential for methane to migrate beneath a structure through the relatively permeable trench backfill whenever new or replacement utility lines (e.g., water, sewer, plumbing, phone, electrical, cable, gas) are installed beneath the building foundation. A relatively impermeable dam or plug constructed of compacted soil (a minimum of 90% compaction), bentonite-soil mixture, sand-cement slurry, or equivalent, should be installed in all utility trenches that are backfilled with sand or other permeable material during new or replacement installation of utility lines. These dams should extend for a distance of at least five (5) feet from the perimeter of the structure and from at least six (6)-inches above the bottom of the perimeter footing to the base of the trench.

7. Conduit Seals

   Conduit seals should be provided at the termination of all utility conduits to reduce the potential for combustible gas migration along the conduit to the interior of the building. These seals should be constructed of inert gas-impermeable material [e.g., closed cell expanding polyurethane foam (EPF), EYS fitting] in compliance with National, California and local Electrical Codes. If closed cell EPF is utilized to construct the seal in unclassified areas (as defined below), the EPF should be located at, or near, the termination of the conduit and it have a minimum length of six (6) conduit diameters or six (6) inches, whichever is greater.

8. Underground Conduits: Buried conduits should be treated according to the appropriate requirements of the National, California and local Electrical Codes. Proper classification of the subsurface soil is important to properly design the underground conduit. The following guidelines are suggested for determining electrical classification, based on the methane content in surface soils in the area within 200 feet horizontally of a structure. The deepest part of structure is extended by any man-made potential pathways (e.g., sub-drains, elevator pistons) below the structure. The actual classification should be reviewed by an environmental assessor [as defined in Education Code section 17210(b)] in conjunction with a professional electrical engineer licensed in California to make specific recommendations for electrical classification.

   a. Unclassified areas

      Subsurface soil classification is not required:

      i. if methane concentrations in subsurface soil are not greater than 12,500 ppmv (1.25%) or methane pressures are less than one (1) psi from ground surface to 20 feet below the deepest part of a structure; and

      ii. if methane concentrations in subsurface soil are not greater than 50,000 ppmv (5%) or methane pressures are less than one (1) psi at depths deeper than 20 feet below the deepest part of a structure.

   b. Class 1 Division 2 Group D

      Subsurface soil should be classified as Class 1 Division 2 Group D:

i. if methane concentrations in the soil are between 12,500 ppmv (1.25%) and 50,000 ppmv (5%) or methane pressures are at one (1) psi or larger from ground surface to 20 feet below the deepest part of a structure; or

ii. if methane concentrations in the soil are greater than 50,000 ppmv (5%) or methane pressures are at one (1) psi or larger at depths deeper than 20 feet below the deepest part of a structure.

c. Class 1 Division 1 Group D

Subsurface soil should be classified as Class 1 Division 1 Group D if methane concentrations in the soil are not less than 50,000 ppmv (5%) from 0 to 20 feet below the deepest part of a structure.

9. Air Emission Permits

Permits or authorizations from the local air pollution control district (APCD) or air quality management district (AQMD) are typically not required for a passive methane collection and venting system (i.e., passive venting of non-landfill methane) that exhausts to atmosphere. However, the local APCD or AQMD should be consulted to determine if compliance with air emission requirements is necessary.

B. Operation and Maintenance Requirements

Typical O&M activities for the improvements described above may include:

1. Routine inspection of the area of concern, including all visible components of the methane venting systems and the multi-stage gas probes, to ensure there are no significant site condition changes and no signs of degradation of the methane remedy system components;

2. Routine monitoring of designated gas probes, lowest accessible floor and enclosed areas of the structures of concern, and grade surface areas to ensure there are no potentially significant changes in subsurface gas concentrations or pressure;

3. Routine monitoring of vent risers for flow rates and gas concentrations to confirm the methane venting systems are functioning as intended; and

4. Other activities, e.g., routine maintenance, calibration and testing of functioning components of the methane venting systems in accordance with the manufacturers' schedule and recommendation, if appropriate.

See Section 8.2 for recommendation on O&M frequency.

C. Special Recommendations for High-Risk Sites

An active collection and vent system or an equivalent system should be considered for **high-risk sites** where a **sustained** soil methane pressure of one (1) psi or above is confirmed. Permits or authorizations from the local APCD or AQMD are typically required for an active methane collection and venting system that includes a fan or a blower, depending on the rate of extraction, the gas composition, etc. Consultation with the local APCD or AQMD for specific requirements is necessary.

For sites where subsurface methane concentrations are above the LEL and a subsurface gas pressure of one (1) psi or more is present, the school site should be carefully evaluated and a deep well pressure relief/vent system or other improvements, which reduce or eliminate subsurface gas levels and/or pressures, should be considered in addition to the building protection system. Mitigation of the elevated gas pressures at these sites may be required as a condition of site approval.

NOTE: Any existing school located within 1,000 feet of a landfill or 100 feet of an oil well (abandoned, inactive or active) should be carefully evaluated as a high risk site.

5.4 Methane Collection, Membrane and Passive Vent Systems

Example: New classroom buildings, where remedies will be installed concurrently with building constructions.

This new structure improvement remedy involves installation of a passive sub-slab methane collection and vent piping and a membrane system for new structures.

A. Design, Operation and Maintenance Requirements

All considerations for the existing structure retrofit remedy (specified in Section 5.3) are also generally applicable for this new structure improvement remedy, except that:

1. If an appropriate permeable bedding material is provided for the collection piping (e.g., sand or gravel), evaluation of native soil permeability characteristics may not be necessary for the pipe spacing design.

2. Gas Barrier/Membrane System should meet the following requirements:

   a. Gas membranes should be constructed with approved materials and thicknesses, e.g., 60-mil or 0.060 inches of high-density polyethylene (HDPE), 100-mil or 0.10 inches of liquid boot or equivalent;

   b. Gas membranes should be placed a maximum of one (1) foot below the floor slab and a maximum of six (6) inches above the gas collection piping;

   c. Protective layers consisting of sand [at a minimum, two (2) inches or thicker] and geotextile [at a minimum, six (6) ounces per square yard] should be laid below and above the membrane;

   d. Without a careful evaluation and confirmation data to support the beneath footing passage, the membrane should not pass below footings and/or stiffener beams of the structure of concern due to seismic concerns;

   e. Gas tight seals (e.g., boots) should be provided at all pipe or conduit penetrations through membrane. Gas tight seals should be provided where the membrane attaches to interior and perimeter footings; and

   f. A smoke test of the membrane system (as recommended by the membrane manufacturer) should be conducted to ensure no leaks exist. Where leaks are identified, appropriate repairs should be undertaken and smoke testing should be repeated until no leaks are detected.

B. Perimeter Methane Monitoring

A perimeter methane monitoring system may be required to evaluate the potential for combustible gas to migrate onto, or off of, the site in question under some circumstances. The perimeter methane monitoring system should include a network of multi-stage soil gas monitoring probes, evenly spaced approximately 1,000 feet apart, and at a minimum of four (4) locations, along the perimeter of the site (between the property boundary and the outside edge of the membrane system). However, placement may vary in order to target permeable soils/features. The multi-stage sampling probes should be installed approximately 5 and 15-feet bgs (if possible, one above and one below the membrane liner elevation), depending upon the geology, depth of fill material, and depth of groundwater at each monitoring probe location.

C. Active Injection of Air Under Buildings

Injecting air into a methane collection system immediately beneath a membrane-protected structure in order to enhance methane venting may be considered, provided that a detailed design has been included so that:

- The system does not create increased pressures under the building that may force methane into the building or into unprotected neighboring properties or structures. Sensors to monitor subslab pressures should be considered.

- The amount of air injected is equal to or less than the flow from vent risers. Sensors to monitor vent riser gas flow should be considered.

- Utility trench dams are included to prevent methane from being forced into utility trenches, pavement subgrade and/or other conduits.

Although an air permit from local APCD or AQMD is typically not required for an active air injection system, the APCD or AQMD should be consulted to determine if compliance with air emission requirements is necessary.

6.0 DTSC METHANE MITIGATION PROJECT APPROVAL PROCESS

If the school district chooses to proceed with site remediation, a RAW as described in Section 25323.1 of the Health and Safety Code will be required to carry out the selected remedies. The typical RAW process may be followed for an excavation remedy or a methane collection and passive vent system remedy. The process for approving a methane RAW with a methane collection, membrane and passive vent system remedy is unique since the methane remedy must be implemented in the design and construction of the school facilities. Such a unique process is described in the following sections.

6.1 Methane RAW with Methane Collection, Membrane and Passive Vent System

Unlike excavation or other cleanup actions, structural improvement remedies for methane concerns should be incorporated into the new school construction design. In order for the methane RAW implementation to occur concurrently with construction of the school facility, DTSC's approval of the methane RAW project will be completed in five (5) phases as described below. A DTSC approval process matrix for all responsible parties is included as Attachment B.

A. Approval of a methane RAW based on an approvable 60% design;

B. Approval of final detailed designs;

C. Field oversight of methane RAW implementation;

D. Certification for school occupancy after approval of the RAW completion report, including final acceptance of the detailed as-built methane mitigation plans and certifications; and

E. Oversight of ongoing operation, maintenance and monitoring activities.

6.2 Approval of Methane RAW with 60% Design

DTSC may approve a methane RAW with a 60% design package that reflects the concepts, principles and proposed layouts of the structure improvement remedies. The school district should contact the Department of Education for issues concerning the state funding process.

The 60% design package should be complete for independent implementation without necessarily considering interface with, or interference by, other building elements or underground utilities. As an appendix to the RAW, the 60% design package should include 60% design plans, specifications, drawings and estimates, prepared by a methane engineer as specified in Section 5.0.

The 60% design package should provide information on construction procedures and materials, specify appropriate construction quality control requirements, identify the projected O&M requirements, and be formatted in accordance with Construction Specifications Institute (CSI) requirements (see website: http://www.csinet.org/). Sixty percent design drawings should detail the components of the methane mitigation systems with dimensions and include drawings for grading/paving, foundation, electrical, structural and mechanical elements which may impact or affect the remedial design of the methane mitigation systems.

At a minimum, three (3) sets of the RAW (including the 60% design package) should be submitted for DTSC review and 60% design approval. After completion of the required public participation activities and DTSC review, DTSC will approve the RAW.

6.3 Approval of Final Detailed Design

Prior to implementation of the approved methane RAW, a final design package should be completed according to the approved methane RAW. The methane engineer (as specified in Section 5.0) will work with the project architect and DSA to conduct a “conflict/feasibility check” for accommodation of the local conditions, e.g., other building elements or utilities, determine the construction dimensions, select the precise locations for the proposed system layout, and prepare final construction drawings. This final design package, including 100% design specifications and drawings, will address how the remedial system will be adapted and fitted to site-specific features. The final design package should be signed and stamped by the methane engineer (as specified in Section 5.0).

At a minimum, three (3) sets of the final design package should be submitted for DTSC review and approval for actual construction. Upon approval of the final design package, DTSC will inform the school district and the DSA. In addition, DSA approval of the final 100% design and drawings package is also needed prior to project bidding and construction.

6.4 Field Oversight

DTSC may provide field oversight during implementation of the RAW. A 48-hour written notification of the following activities should be provided to DTSC:

A. Remedy material acceptance;

B. Final grading and preparation;

C. Installation of sub-slab combustible gas collection piping system;

D. Installation of gas membrane systems;

E. Bedding and backfill;

F. Installation of vent piping system; and

G. Post construction testing, including smoke testing of seams and penetrations, vent riser flow monitoring, gas probe monitoring, indoor air monitoring, and vent capacity testing.

DTSC will organize a project team for each project to closely monitor the above activities. Team members may include project senior, project manager, geologists, engineers, scientists, and industrial hygienist. A checklist for field inspection is included as Attachment C. Additional requirements, changes or relocations may be deemed necessary during the field oversight activities. As part of the project quality assurance and quality control (QA/QC) program, an inspection and conformance program should be implemented by the school district.

6.5 Change Order(s) During Construction of Methane Remedies

When a change order is necessary during construction of methane remedies, the methane engineer (as specified in Section 5.0) should evaluate and determine the nature whether the change is minor or major. A major change means a substantial change to the design layout, material, operation, construction methods or costs (i.e., more than $5,000.00) of the approved system design. The school district may proceed with a minor change after receipt of verbal approval from DTSC. A written approval should be obtained from DTSC prior to implementing a major change. DTSC will expedite its review of a major change.

7.0 CERTIFICATION

Where DTSC requires a response action at a school site, Education Code section 17213.2, subsection (d)(2), provides that the school district may not occupy a school building following construction until it obtains a certification from DTSC. The certification indicates that post-RAW site conditions including ongoing O&M activities do not pose a significant risk to human health or the environment. DTSC will issue certification for school sites where O&M activities are required, when all of the following conditions have been met:

- Completion of all necessary response actions, except for ongoing operation and maintenance activities if required;
- Compliance with the approved response action standards and objectives;
- Issuance of DTSC approval of the RAW Completion Report, including detailed as-built methane mitigation plans, drawings and certifications; and
- Execution of a required O&M Agreement between the school district and DTSC for implementation of the approved O&M Plan.

The final O&M Plan, as modified and/or approved, should be implemented upon installation of mitigation measures, and remain in effect until DTSC releases the school district in writing from its implementation, pursuant to termination procedures specified in the O&M Agreement. At a minimum, a first run of O&M (inspection and monitoring) activities should be conducted as part of the RAW completion certification and data be included in the RAW Completion Report.

8.0 OPERATION AND MAINTENANCE

When the selected remedy includes long-term O&M activities, an O&M Agreement is required prior to site certification. The O&M Agreement is an enforceable document which requires the school district to implement the required O&M activities in accordance with an approved O&M Plan under DTSC oversight.

8.1 Operation and Maintenance Plan

An O&M Plan should be reviewed and approved by DTSC **prior to** site certification. The objective of the O&M Plan is to describe in detail the procedures required for continued operation and monitoring of the mitigation measures. The O&M Plan should include a detailed description of the mitigation system and its components, as well as comprehensive protocols for operation, monitoring, data acquisition, reporting, and maintenance activities. An outline of a typical O&M Plan is included as Attachment D. Main components of a typical O&M Plan are discussed in the following sections.

8.2 Frequency

The O&M activities should be performed, at a minimum, on a monthly basis and after each significant seismic event, following completion of construction. Specific O&M activities after a significant seismic event are recommended in Section 8.5.F. A significant seismic event is defined as below:

A. An earthquake of 5.0 on the Richter scale recorded at a seismometer station within 10 miles of the site; or

B. An actuation of an earthquake actuated automatic gas shutoff device/valve at the site during an earthquake.

Based upon site specific monitoring results and conditions, the frequency and/or scope of subsequent O&M activities may be modified (e.g., the frequency is changed from monthly to quarterly) in consultation with DTSC. Once the long-term performance of the methane mitigation system is confirmed and/or subsurface gas concentrations attenuate to non-regulated levels (based on the trend of O&M results), DTSC may allow all O&M activities be terminated after an evaluation of the latest five (5)-year review report (see Section 9.0).

8.3 Qualifications of Operation and Maintenance Personnel

All O&M activities should be performed by qualified personnel who have been properly trained and authorized to conduct such activities, under the direction and supervision of a qualified methane engineer (as specified in Section 5.0). The methane engineer should be familiar with the methane remedy system installed at the site.

8.4 Maintenance and Repair

The methane remedy system will not require maintenance under normal circumstances. If inspection and monitoring activities suggest the methane remedy system is in need of maintenance or repair, the school district should initiate appropriate action in consultation with DTSC.

Prior to any construction or repair activities that may affect the methane remedy system, the school district should submit a workplan to DTSC for review and approval. These activities may include, but are not limited to, addition of portable structures, removal of building floor slabs, penetrations through the gas membrane or any improvements that could expose gas membrane and/or vent piping, improvements or alterations to vent risers, subsurface permanent gas probes, or other components of the methane remedy system.

8.5 Contingency Plan

A Contingency Plan should be developed for use by school officials and O&M personnel to assist in selecting an appropriate response action and providing guidance in evaluating the concentration of methane in buildings and enclosed areas, exterior paved areas and exterior open areas. A copy of the Contingency Plan and all revisions to the plan should be maintained at the school and submitted to the DTSC, local fire authority and emergency response teams that may be called upon to provide emergency services. At all times, there should be at least one school employee either on the school campus or on call with the responsibility for coordinating all emergency response measures due to methane concerns.

In the event of contingencies, emergencies or failures of the methane remedy systems, the Contingency Plan should be activated and implemented.

DTSC recommends the following criteria be used to evaluate the safety of school occupants and initiate appropriate response actions, if needed:

A. Ventilation Layer Monitoring

If the concentration of methane gas in the ventilation layer (e.g., crawl spaces) beneath buildings, exterior paved areas and/or exterior open areas consistently exceeds two (2) percent of the LEL (i.e., 1,000 ppmv) for methane, the following immediate responses should be taken:

1. The indoor air exchange rate of the Heating, Ventilation and Air Conditioning (HVAC) system should be increased (e.g., to a level of at least two full air exchanges per hour); and

2. The affected buildings should be monitored until the elevated methane concentrations are reduced below 1,000 ppmv.

In addition, the level of ventilation in the crawl space or other areas where elevated methane concentrations are detected should be enhanced.

B. Vent Riser Monitoring

If a significant increase of 5,000 ppmv or more from the previous monitoring event, or exceeding of 12,500 ppmv, in methane concentrations is detected at vent riser outlets, the following responses should be taken immediately:

1. The building HVAC system should be activated to increase the air exchange within the building (e.g., to a level of at least two full air exchanges per hour);

2. A sweep monitoring of the lowest level interior spaces should be performed; and

3. DTSC should be notified within 24 hours of such an event and the monitoring frequency should be increased in consultation with DTSC (e.g., by a factor of two).

C. <u>Subsurface Probe Monitoring</u>

If a significant increase of 5,000 ppmv or more in methane concentrations, or 0.1 psi or more in methane pressure, from the previous monitoring event is detected at an onsite permanent subsurface probe, DTSC should be notified within 24 hours of such a detection and the monitoring frequency of subsurface probes should be increased in consultation with DTSC (e.g., by a factor of two).

D. <u>Indoor Methane Monitoring</u>

If indoor methane gas concentrations exceed 1% of the LEL (i.e., 500 ppmv) for methane, the following responses should be taken immediately:

1. The building HVAC system should be activated until a monitoring of the entire lowest level interior spaces confirms that methane concentrations are reduced and maintained below 500 ppmv; and

2. DTSC should be notified within 24 hours of such an event and the monitoring frequency should be increased in consultation with DTSC (e.g., by a factor of two).

E. <u>Evacuation</u>

If indoor methane gas concentrations exceed 10% of the LEL (i.e., 5,000 ppmv) for methane, the following responses should be taken immediately:

1. The local fire authority should be notified immediately;

2. The buildings should be evacuated until the source of the methane intrusion is identified and abated; and

3. DTSC should be notified within 24 hours of such an event and the monitoring frequency should be increased in consultation with DTSC (e.g., by a factor of four).

F. Significant Seismic Events

The following O&M (inspection and testing) activities should be conducted after each significant seismic event (as defined in Section 8.2):

1. Level I O&M Activities

   Conduct a visual inspection of interior and exterior of mitigated structures, including vent risers and conduit seals. Perform complete round of monitoring of any onsite gas probes or other methane monitoring devices. Identify, evaluate, and report any anomalies.

   If foundation displacement or structural damage is evident, or if a significant increase (e.g., more than 5,000 ppmv) in methane concentrations at methane gas probes or monitoring devices is detected, perform Level II O&M activities.

2. Level II O&M Activities

   Screen for elevated combustible gas levels on the interior of mitigated structures, and around the perimeter of the structure foundation. Take measurements during period of falling barometric pressure. Confirm positive outflow of soil gas at vent riser outlets during diurnal decrease in barometric pressure. Identify, evaluate, and report any anomalies.

   If a significant increase (e.g., more than twice of last detected concentration and more than 500 ppmv) in interior methane concentrations is detected, perform Level III O&M activities.

3. Level III O&M Activities

   Conduct a smoke test of the sub-slab vent system to confirm the Integrity of the methane remedy system with non-toxic smoke injected through vent riser outlets under a pressure of 4" to 6" of water. Confirm connectivity of all vent risers. Screen for emergence of smoke on interior of structure. Identify and repair ay leaks/penetrations in gas membrane or vent risers. Repeat smoke tests following completion of any repairs.

8.6 Operation and Maintenance Reports

An O&M report should be submitted to DTSC within 30 days after each O&M event (routinely scheduled or after each significant seismic event) to DTSC for review and approval. Reports should include:

A. Results of visual inspection;

B. Results of sample analyses and tests;

C. Description of actions taken since completion of the previous O&M event, including:

   1. Any repairs to gas mitigation improvements that were carried out or needed;

   2. Any significant changes in site conditions or usage, e.g., paving, grading, utility trenching, playgrounds, or picnic areas; and

   3. Any additional onsite construction or other significant information that may relate to the gas mitigation improvements or impact their function, e.g., installation of portables or maintenance facilities.

D. Description of any findings identified during the current O&M event; and

E. Description of actions planned or expected to be undertaken before the next O&M event.

DTSC will review each O&M report. Based upon the review, additional methane investigation, monitoring and/or mitigation may be required.

8.7 <u>Five (5)-Year Review Report</u>

A five-year review of the completed remedial or removal action should be conducted no less often than every five (5) years after initiation of the selected remedial or removal action. A five-year review report should be submitted within 30 days after each scheduled five-year review to DTSC for review and approval. Reports should include the following components: Introduction, Site Background, Site Chronology, Removal Actions, Progress Since Last Review, Five-Year Review Process, Technical Assessment, Issues, and Conclusions and Recommendations.

The technical assessment (of the protectiveness of the remedy) of the five (5)-year review should address the following questions:

A. Is the remedy functioning as intended by the decision documents?

B. Are the removal action objectives, goals and criteria used at the time of the remedy selection still valid?

C. Have there been any significant changes in the distribution, concentration, or pressure of the subsurface gas at the site?

D. Has any other information come to light that could call into question the protectiveness of the remedy?

DTSC will review each five (5)-year review report. Based upon the review, additional methane investigation, monitoring and/or mitigation may be required.

9.0 SYSTEM CLOSURE AND DECOMMISSIONING

Based on review of the first Five-Year Review Report or a subsequent O&M report, DTSC may determine if the methane mitigation system has met the following performance criteria required for termination of O&M activities:

- Methane concentrations of less than 5,000 ppmv in all onsite subsurface permanent gas probes have been consistently demonstrated at least twice and over one (1) year of monitoring;

- Methane concentrations of less than 500 ppmv in crawlspaces, utility boxes, and indoor air have been consistently demonstrated at least twice and over one (1) year of monitoring; and

- Methane concentrations of less than 1,000 ppmv in vent risers have been consistently demonstrated at least twice and over one (1) year of monitoring.

DTSC will notify the school district in writing when continued O&M activities of the methane mitigation system are no longer required. The methane mitigation system improvements are not anticipated to have an adverse impact on building foundation systems or other components. Accordingly, removal or decommissioning of the methane mitigation improvements following termination of the O&M activities of the methane mitigation system will not be required.

10.0 REFERENCES

Additional information may be found in the following documents:

A. Methane Mitigation Standards, City of Los Angeles, Department of Building and Safety (www.ladbs.org/rpt_code_pub/methane.htm), February 3, 2004

B. Development and Land Use Guideline for Combustible Soil Gas Hazard Mitigation, Guideline C-03, Orange County Fire Authority, Planning and Development Services Section, January 31, 2000 (www.ocfa.org/business/pandd/guidelin.htm)

C. San Diego County Code of Regulatory Ordinances, Title 8 Zoning and Land Use Regulations, Division 6, Chapter 3 Methane Gas Testing in the Unincorporated Areas of San Diego County (www.amlegal.com/sandiego_county_ca/)

D. Methane Mitigation Protocol (Vacant Lots), Riverside County Health Services Agency, Department of Environmental Health, July 27, 2001 (Contact: Chuck Strey at 909-955-4053)

E. Building Code 17.04.085, City of Huntington Beach, July 1999 (www.hb-building.org/)

F. Ordinance No. 96-769, Amending Chapter 15-08 (Fire Code), City of Yorba Linda

G. California Code of Regulations, Title 27, Division 2, Subdivision 1, Chapter 3.0, Subchapter 4, Article 6, Gas Monitoring and Control at Active and Closed Disposal Sites, California Integrated Waste Management Board

H. California Code of Regulations, Title 14, Chapter 4, Department of Conservation, Division of Oil, Gas, and Geothermal Resources

I. Preliminary Draft Soil Gas Mitigation Standard 3384, Summary Report, San Diego Gas and Electric, March 15, 2001

J. Advisory – Active Soil Gas Investigations, Department of Toxic Substances Control, January 2003 (www.dtsc.ca.gov/)

K. Interim Guidance for Active Soil Gas Investigation, California Regional Water Quality Control Board, Los Angeles Region, February 25, 1997

L. Information Advisory - Clean Imported Fill Material, Department of Toxic Substances Control, October 2001 (www.dtsc.ca.gov/)

M. Methane Gas Mitigation Discussion at DTSC for Woodcrest School, GeoKinetics, Inc., January 4, 2001

N. Preliminary Methane Gas Site Investigation and Mitigation Guidelines (Draft), GeoKinetics, Inc., March 22, 2002

O. Methane Gas Plan Protection System, County of Los Angeles, Department of Public Works, Environmental Programs Division (Contact: Mr. Carlos Ruiz at 626-458-3502)

O&M References:

A. DTSC Management Memo #EO-93-036-MM, titled "Operation and Maintenance Enforceable Agreement (02/07/94)."

B. Memo to Division Chiefs and Branch Chiefs from Stanley R. Phillipe, titled "Completions for Site Mitigation Program," (06/19/95)

C. U.S. EPA Fact Sheet, titled "Operation and Maintenance in the Superfund Program," OSWER 9200.1-37FS, EPA 540-F-01-004, May 2001

D. U.S. EPA Comprehensive Five-Year Review Guidance, U.S. EPA 540R-01-007, OSWER No. 9355.7-03 B-P, June 2001

E. U.S. EPA Fact Sheet, titled "Structure and Components of Five-Year Reviews," Directive 9355.7-02FSI, August 1991

F. U.S.EPA Fact Sheet, titled "Five-Year Review Process in the Superfund Program," OSWER Directive 9355.7-08FS, EPA 540-F-02-004, April 2003

FOR MORE INFORMATION

Please contact the following person if you need additional information or if you have comments:

Mr. Ken Chiang
Department of Toxic Substances Control
School Property Evaluation and Cleanup Division
1011 North Grandview Avenue
Glendale, California 91201
(818)551-2860
kchiang@dtsc.ca.gov

ATTACHMENT A

Table 1: Relative Flow Capacities of Methane Vent Risers

Pipe Diameter (Inches)	***Flow Capacity Relative to 2-Inch Pipe***
1.5	***46%***
2.0	***100%***
2.5	***181%***
3.0	***295%***
4.0	***635%***

Note: Relative Flow Capacities are for Standard Size, Nominal Diameter, Schedule 40 Pipe

ATTACHMENT B

DTSC APPROVAL PROCESS MATRIX

Methane Related Removal Action Workplan(s); Proposed Responsibility Matrix

	DESIGNER	DTSC	DSA	DIST - FAC	DIST - OEHS	ARCH	CONTRACTOR	IOR
Design System	P	O	-	R	M	R&S	-	-
Incorporate Design	S	-	O	R	R	P	-	-
RAW Approval	-	P	-	S	M	-	-	-
DTSC Design Approval	-	P	S	S	M	R	-	-
Plan Approval	-	-	P	M	-	S	-	-
Bid Documents	S	-	-	M	R	P	-	-
Construct System	O	O	-	M	O	O	P	I
Test System	O	O	-	M	O	-	P	S
O&M Plan + Agreement	R	P	-	M	R	-	-	-
RAW Certification	-	P	-	M	S	-	-	-
Certify School Occupancy	-	R	S	S	S	S	-	P

Definitions:

DESIGNER	Methane Mitigation System Engineer/Designer
DTSC	Department of Toxic Substances Control
DSA	Department of State Architects
DIST – FAC	District Office of Facility Management
DIST – OEHS	District Office of Environmental Health & Safety
ARCH	Project Architect
CONTRACTOR	Methane Mitigation System Contractor
IOR	Inspector of Record
P	Primary
S	Secondary
R	Review
O	Oversight
M	Manage
I	Inspect

ATTACHMENT C
FIELD INSPECTION CHECKLIST

Methane Gas Mitigation **Single-Pour Foundation Inspection Form**	**Mitigation Plans Dated:**__________ **Lot No.:** __________ **By:**__________ **Tract No.:** __________

Material Approval

	DESCRIPTION	APPROVED
Sub-slab vent pipe		
Sub-slab vent filter fabric		
Sub-slab vent trench back fill material		
Sub-slab vent pipe to concrete protection material		
Gas membrane		
Gas membrane bonding tape		
Gas membrane pipe boots		
Vent riser pipe		
Vent riser rain cap		
Conduit Sealant Material		
Utility Dam Material		

Sub-Slab Vent Piping

	INSPECTOR	OK	NOT OK	NOTE #	INSPECTION DATE	CORRECTION DATE
Configuration of piping consistent with approved plans (Attach floor plan documenting any deviations)						
Proper transitions through footings						
Sand/Gravel below membrane: suitability and thickness of installation (_______ Inches)						
Vent pipe positioning within collection blanket						
End caps properly installed						
Proper connection for active vent system						
Filter fabric properly installed						
Vent piping foam taped through footings						
Vent risers properly secured to form boards						
Final sub-slab vent pipe inspection--Ok to pour footings and install sand on sub-grade						

Gas Membrane

	INSPECTOR	OK	NOT OK	NOTE #	INSPECTION DATE	CORRECTION DATE
Proper stemwall/footing finish for membrane bonding						
Gas membrane continuously bonded to perimeter footings						
Geofabric placement acceptable						
Gas membrane continuously bonded to Interior footings						
Gas membrane seems continuously sealed						
Pipe boots properly installed and sealed						
Membrane properly sealed to sewer backflow valve conduit						
Membrane smoke testing successfully completed						
Ok to install sand on membrane						
Sand/gravel above membrane: suitability and thickness of installation (_______ Inches)						
Final membrane inspection--Ok to pour slab						
Slab pouring/finishing protocol observed and acceptable with respect to protection of gas membrane						
Slab membrane identification plate(s) properly installed						

Vent Risers

	INSPECTOR	OK	NOT OK	NOTE #	INSPECTION DATE	CORRECTION DATE
Vent riser location consistent with approved plans						
Vent risers (do not penetrate)(properly penetrate) framing members						
Vent riser holes through sill plate and top plate properly placed & dimensioned						
Structural straps properly installed on sill & top plates where required						
Nail plate properly installed on blocking where required						
Vent pipe joints properly sealed						
Vent pipe properly secured/strapped where exposed						
Vent pipe properly stubbed through roof sheathing						
Vent pipe outlet has proper roof clearance						
Vent pipe outlet has proper clearance with respect to windows, etc.						
Vent pipe rain cap properly installed						
Vent pipe methane labels properly installed						

Utility Seals

	INSPECTOR	OK	NOT OK	NOTE #	INSPECTION DATE	CORRECTION DATE
Conduit Seals Properly Installed						
Utility Trench Backfilled with Cement Bentonite Slurry or Native Material Compacted to 90% Relative compaction						

Final system approval

Inspector Signature:______________________ Inspector Name:______________________ Date: ____________

(DOC.PUB.4.02.02)

ATTACHMENT D

OPERATION AND MAINTENANCE PLAN OUTLINE

1. 0 INTRODUCTION
- 1.1 Purposes and Uses
- 1.2 Health and Safety Summary
- 1.3 O&M Personnel Qualifications
- 1.4 O&M Organization Chart
- 1.5 Modification or Update Procedures

2.0 SITE BACKGROUND

3.0 OVERVIEW OF THE METHANE REMEDY SYSTEMS
- 3.1 Gas Monitoring Probes
- 3.2 Passive Ventilation Systems
  - 3.2.1 System Description and As-Built Drawings
  - 3.2.1 Protocols for Activities Potentially Affecting the Systems
- 3.3 Impervious Membrane Liner Systems
  - 3.3.1 System Description and As-Built Drawings
  - 3.3.2 Protocols for Activities Potentially Affecting the Systems
- 3.4 System Operations

4.0 INSPECTION PROCEDURES, SCHEDULE AND CHECKLIST
- 4.1 Routine Inspection
  - 4.1.1 Site Conditions
  - 4.1.2 Remedy System Conditions
  - 4.1.3 Inspection Schedule and Checklist
- 4.2 Remedy System Maintenance and Repair
  - 4.2.1 Maintenance and Repair Procedures
  - 4.2.2 Trouble-Shooting
  - 4.2.3 Spare Parts Lists
  - 4.2.4 Maintenance Schedule and Checklist
- 4.3 Confined Space Entry

5.0 MONITORING PROCEDURES, SCHEDULE AND CHECKLIST
- 5.1 Ambient Air Monitoring – Methane Concentrations
- 5.2 Gas Probe Measurement - Methane Concentrations and Pressures
- 5.3 Vent Riser Measurement - Methane Concentrations and Pressures
- 5.4 Methane Sampling and Analysis
- 5.5 Monitoring Schedule and Checklist

6.0 FIVE-YEAR REVIEW

7.0 DATA COLLECTION, DOCUMENTATION, AND REPORTING
- 7.1 Data Collection
- 7.2 Data Assessment
- 7.3 O&M Reports
- 7.4 5-Year Review Reports

8.0 CONTINGENCY PLAN
- 8.1 Contingency Criteria
- 8.2 Appropriate Response Actions
- 8.3 Incident Report

APPENDIX A Health and Safety Plan
APPENDIX B Organization Chart
APPENDIX C As-Built Drawings
APPENDIX D Quality Assurance Project Plan