

File No.: 2026-351

August 12, 2026

s.22(1)

Dear s.22(1)

Re: **Request for Access to Records under the Freedom of Information and Protection of Privacy Act (the "Act")**

I am responding to your request of April 22, 2026 under the ***Freedom of Information and Protection of Privacy Act*** for:

Record of South False Creek Soil Gas Emissions Study – March 1999, relating to 1505 West 2nd Avenue. Date range: March 1, 1999 to March 31, 1999.

All responsive records are attached.

Under Part 5 of the Act, you may ask the Information & Privacy Commissioner to review any matter related to the City's response to your FOI request by writing to: Office of the Information & Privacy Commissioner, info@oipc.bc.ca or by phoning 250-387-5629.

If you request a review, please provide the Commissioner's office with: 1) the request number (2026-351); 2) a copy of this letter; 3) a copy of your original request; and 4) detailed reasons why you are seeking the review.

Yours truly,

Kevin Tuerlings, FOI Case Manager, for

[Signed by Kevin Tuerlings]

Siân Madsen, MA, MAS
Acting Director, Access to Information & Privacy

If you have any questions, please email us at foi@vancouver.ca and we will respond to you as soon as possible. You may also contact 3-1-1 (604-873-7000) if you require accommodation or do not have access to email.

Encl. (Response Package)

:pm

Building numbers pertains to the "South Shore False Creek Gas Vapour Survey"
(Prepared by: Environmental Protection Branch , CoV - October 1998)

Building No. as per Report	Address
1	1483 Lamey's Mill Road
2	1465 Lamey's Mill Road
3	1415 Lamey's Mill Road
4	1377 Lamey's Mill Road
5	1477 Fountain Way
6	1425 Lamey's Mill Road
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	1201 Lamey's Mill Road
17	
18	
19	1150 Forge Walk
20	1150 Forge Walk
21	1150 Forge Walk
22	1150 Forge Walk
23	1000 - 1038 Ironwork Passage
24	1167 Forge Walk
25	1075 - 1089 Scantlings
26	1031 - 1049 Scantlings
27	1000 - 1038 Ironwork Passage
28	1000 - 1038 Ironwork Passage
29	1000 - 1038 Ironwork Passage
30	900 School Green
31	
32	
33	
34	
35	
36	721 Millyard
37	
38	
39	
40	
41	
42	807 Sawcut

43	807 Sawcut
44	807 Sawcut
45	807 Sawcut
46	673 Market Hill, 674 Leg-in-Boot Square, 682 698 Millbank
47	673 Moberly Road
48	673 Moberly Road
49	650 Bucketwheel Road
50	666 Leg-in-Boot Square, 650 Moberly Road
51	619 - 627 Moberly Road, 633 Bucketwheel
52	522 Moberly Road
53	518 Moberly Road
54	527 Commodore Road
55	1893 Spyglass Place
56	1873 Spyglass Place
57	1869 Spyglass Place
58	1869 Spyglass Place
59	1859 Spyglass Place
60	650 Moberly Road
61	1502 Island Park Walk
62	1551 & 1508 Mariner Walk
63	1551 Mariner Walk
64	1590 - 1598 Island Park Way & 1591 - 1511
65	Mariner Walk
66	
67	1510 West 1st Avenue
68	1550 Mariner Walk
69	1540 Mariner Walk
70	1530 Mariner Walk
71	1551 & 1508 Mariner Walk
72	1515 West 2nd Avenue
73	1505 West 2nd Avenue
74	1515 West 1st Avenue
75	1490 Pennyfarthing Drive
76	1470 Pennyfarthing Drive
77	1450 pennyfarthing Drive
78	1441 Creekside Drive
79	1440 - 1450 Creekside Drive
80	1505 West 1st Avenue
81	456 Moberly
82	609 Stamp Landing
83	609 Stamp Landing
84	525 Wheel House Square
85	1800 Spyglass Place

PREPARED FOR

THE CITY OF VANCOUVER
CITY BUILDING INSPECTOR

FINAL REPORT

SOUTH FALSE CREEK
SOIL GAS EMISSIONS STUDY

Prepared by:



CG&S

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March 1999

EXECUTIVE SUMMARY

This report is intended to provide guidance to the City of Vancouver relating to possible soil gas emissions on the south shore of False Creek. This request was in response to an explosion that occurred on September 14, 1998 in the basement electrical vault of the Alder Bay Cooperative Housing Complex in South False Creek. Although the explosion was initially thought to be due to an accumulation of explosive soil gases in the electrical vault, the cause of the explosion has been subsequently attributed to an electrical short in a buried electrical service cable leading to the electrical vault.

Immediately after the September 1998 explosion, a gas testing program was carried out by the City of Vancouver Environmental Protection Branch to determine if there was a risk to public safety in other buildings. All buildings located on the south shore of False Creek between Cambie Street, Burrard Street, and Lameys Mill Road to the south and the foreshore to the north were inspected for methane and hydrogen sulphide gases (See Figure 1-1 for building locations). The findings of the survey are summarized in the October 1998 report entitled "South False Creek Gas Vapour Survey".

The scope of this report includes the following:

- An evaluation of the gas testing program which was performed by City staff
- A literature review of existing regulations, guidelines and standards in other jurisdictions
- Development of proposed action level criteria for methane gas in buildings
- An evaluation of the level of risk associated with building safety due to potential soil gas emissions in the South False Creek area.

False Creek was once a tidal marsh area that later developed into an industrial harbour and most recently into residential development. As an industrial harbour, the primary industries were sawmill, lumber, and metalwork companies. As the area developed, there was extensive infilling with sawdust, wood and other wastes left behind from previous users. As a result of these activities and False Creek previously being a marsh, biogas was generated from this organic matter. This creates a situation similar to what occurs with landfill gas migration. No landfills are known to exist in the area.

Although most of the documents collected through the literature review relate to landfill gas, this information is nevertheless applicable to the False Creek situation. The mid-air, point-of entry and soil gas action level criteria developed in this report were from data collected from the literature search. These action level criteria were developed to identify buildings in the study area that require attention but are also intended for use in future monitoring efforts.

The evaluation of the gas vapour survey report concluded that the area covered by the City survey was sufficient to ensure all buildings exposed to the potential risk of an explosion were inspected. The Alder Bay Cooperative Housing complex and the area immediately east of the Cambie Street were not covered by the City survey and were being assessed or inspected by others. The survey was conducted in a thorough manner using equipment

appropriate for detecting methane and hydrogen sulphide. The sampling methods were sound and the sampling locations within the buildings were appropriate. Quality assurance/quality control measures were also carried out during the survey.

The report recommends adopting a series of "Action Level Criteria" and follow-up "Action Requirements" in connection with the gas monitoring survey for the study area.

The recommended action levels identified some buildings requiring further attention (details in Section 6: Conclusions and Recommendations). The report recommendations include:

- A follow-up visit by the City to Buildings #58, #59, #84 and #53 to ensure that requested corrective action and repairs have been completed. Also conduct a second set of mid-air and point-of-entry readings at these buildings. Compare the results to the recommended action level criteria and complete the "Required Actions" stated in the action level criteria.
- Conduct additional quarterly monitoring at all sample points in buildings along the south shore of False Creek. Those sample points with zero readings for four consecutive monitoring events may be removed from the monitoring program.
- Determine if the methane in buildings at concentrations exceeding the recommended action levels is due to sewer gas or from sources inside the building (Buildings #46, #53, #58, #59, #84, #70, #72 and #73) and take the necessary corrective action.
- Install soil gas probes adjacent to these buildings if the detected combustible gas is not sewer gas or from a source inside the building and methane concentrations are 20% LEL or greater at point of entry locations (2nd Level Point-of-Entry action level criterion). Take soil gas readings and take corrective action according to the "Required Actions" if the methane concentrations exceed the "Soil Gas Action Levels". If soil gas readings are below the action level concentrations, continue with quarterly monitoring inside and outside the buildings (*mid-air, point-of-entry and soil gas* readings).
- Install the necessary components in order to complete the underslab gas venting systems for Buildings #58, #59 and #84. Activate these systems if the combustible gas found in the underslab piping is not sewer gas or from a source inside the building.
- Carry out a monitoring program similar to the City's gas vapour survey for explosive gases at utility and enclosed underground facilities located in the study area, particularly those utility structures adjacent to buildings where methane has been found inside the building. Compare field readings to the recommended action level criteria and complete corrective actions stated in the "Required Actions" if methane concentrations exceed these action levels.
- All new buildings in the area should be evaluated by a professional engineer or geoscientist to determine the need for gas protection measures. These measures should be implemented as recommended by the qualified professionals.

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SECTION 1 INTRODUCTION

1.1 Project Background

On September 14, 1998 there was an explosion in a transformer vault and BC Hydro cable duct at the Alder Bay Co-operative Housing Complex in South False Creek. The Fire Department detected methane and hydrogen sulphide gases in drains in the Alder Bay area immediately following the explosion. For this reason it was initially thought that the explosion was caused by an accumulation of methane gas, sparked by an electrical arc on one of the transformers. This hypothesis was later proven to be wrong after investigations by B.C. Hydro, B.C. Research and Powertech concluded that the cause of the explosion was due to an electrical fault.

The explosion prompted an investigative response from the City of Vancouver's Environmental Protection Branch. A comprehensive inspection program to search for explosive gases in buildings occupying the south shore of False Creek was carried out by City staff. The subject area consists of lands bounded by Burrard Street to the west, Cambie Street to the east, Lamby Mill Road to the south, and extending to the False Creek foreshore to the North (see Figure 1-1). The City survey documents methane and hydrogen sulphide (H_2S) gas concentrations in below-grade or slab-on-grade structures in the October 1998 report entitled "South Shore False Creek Gas Vapour Survey".

1.2 History of Subject Area

Historically, False Creek was a tidal marsh area that developed into an industrial site. The south shore was an industrial harbour for almost a century before residential development commenced in the 1970's. Primary industries along the shoreline throughout this earlier period were sawmill and lumber companies. As a result, deposits of sawdust, wood and other wastes were distributed throughout the area.

The methane that has been detected on the south shore of False Creek is from the previous marshy conditions and previous industrial use on the south shore of False Creek. This creates a situation similar to landfill gas migration.

1.3 Project Scope

The City Building Inspector commissioned this study to review public safety issues within buildings associated with potential soil gas emission in the South False Creek subject area. CH2M Gore & Storrie Ltd. (CG&S) was retained by the City of Vancouver to:

- Advise on the adequacy of the testing program carried out by City staff to evaluate the potential for hazardous accumulations of gas, and to recommend what additional testing or monitoring should be carried out.
- Review research papers on this subject and similar cases in other cities and to summarize the measures taken in other jurisdictions.
- Report on the risks, if any, associated with the levels of gas found to be present and to recommend the range of measures that may be necessary to mitigate that risk.
- Identify any relevant standards for acceptable concentrations of methane in buildings which could be adopted in Vancouver.

The scope of this study includes:

- An evaluation of the testing program carried out by City staff.
- An in-depth literature review to identify relevant guidelines, criteria, standards, and regulations in other jurisdictions.
- Development of action level criteria for methane gas.
- A qualitative assessment of the risk posed by existing conditions in the soil gas emissions as reported in the City survey.

This report is intended to provide guidance to the City of Vancouver regarding possible soil gas emissions in the subject area.

1.4 Properties of Methane Gas

Methane gas (CH_4) is produced in nature during anaerobic decomposition of organic matter by methanogenic bacteria. It is a colourless, odourless, tasteless gas that is less dense than air. Methane gas poses two risks:

- Explosion
- Asphyxiation.

Explosive gases are explosive when they are mixed with air and within a concentration range defined by the lower and upper explosive limit. The minimum concentration necessary for combustion is called the lower explosive limit (LEL) and the maximum concentration, the upper explosive limit (UEL). Methane gas is explosive at concentrations between 5% (LEL) and 15% (UEL) by volume in air but may ignite and burn even when the concentration is above the UEL concentration. Efforts to establish values pertaining to allowable concentrations of explosive gases are always based on the LEL.

Elevated methane concentrations can cause asphyxiation through displacement of oxygen. The British Columbia Workers' Compensation Board (BCWCB) classifies air containing less than 19.5% oxygen by volume as oxygen deficient.

1.5 Properties of Hydrogen Sulphide Gas

Hydrogen Sulphide (H_2S) gas is produced in nature during anaerobic decomposition of organic matter by sulphur-reducing bacteria. It is a colourless gas, often characterized by its rotten egg smell. It is more dense than air and will stratify below air. H_2S gas poses two risks:

- Accute toxicity to humans, and
- Explosion.

H_2S gas attacks the nerves in the nose. At concentrations of 10 ppm and above, protective equipment such as breathing apparatus must be worn. At a concentrations of 500 ppm H_2S gas attacks the nerve center in the brain. The concentration range in which H_2S gas is explosive is 4.3% to 45% by volume in air. Typical effects of different concentrations of H_2S are summarized in Table 1-1.

Table 1-1: Effects of H_2S (Ref. 4)		
Concentration (ppm)	Exposure	Effect
0.72		Normal background level
0.02 – 20		Rotten egg odour detection
0.3 – 5	Short term – Several hours to several days	Headaches, nausea, vomiting, loss of reasoning ability
10	Several hours to several days	Eye effects such as irritation, tearing, inflammation with distorted vision, respiratory irritation and inflammation
20 – 50	Short term	Change in perception of odour or inability to smell odour at all
50	Several hours	Pulmonary edema, which decreases the ability to breath effectively
1,000	Few breaths	Immediate loss of consciousness may occur, respiratory paralysis, death
40,000		LEL

A glossary of terms used in this report is presented in Appendix A.

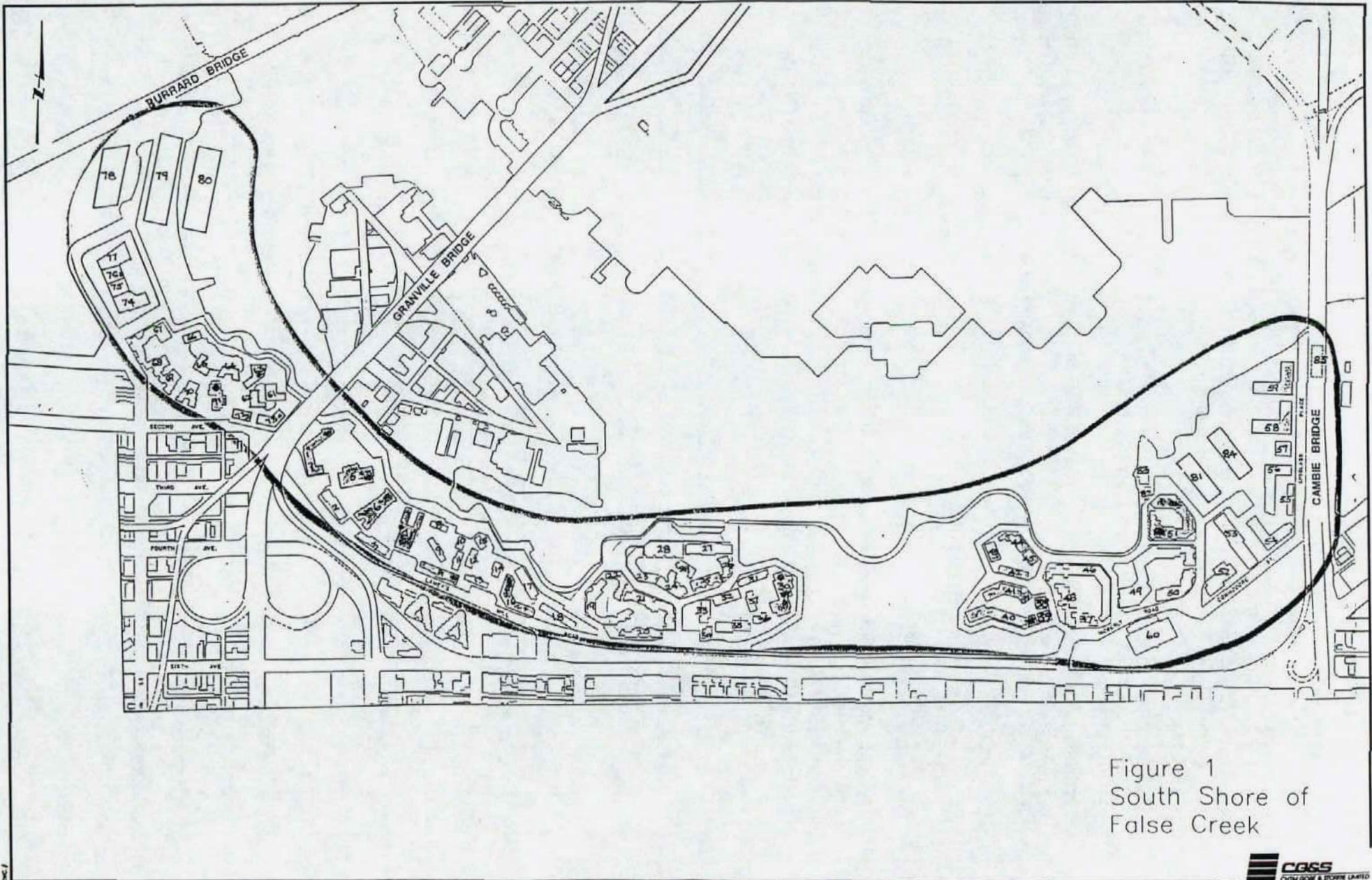


Figure 1
South Shore of
False Creek

SECTION 2 EVALUATION OF THE CITY OF VANCOUVER'S GAS TESTING PROGRAM

The gas testing program carried out by the City of Vancouver Environmental Protection Branch is summarized in the October 1998 City report entitled "South Shore False Creek Gas Vapour Survey". This report has been reviewed with the following objectives:

- Do the data collected represent the subject area?
- Did the equipment and sampling procedures meet the City's project objectives?
- Have public safety concerns been addressed sufficiently?

This section describes the City's sampling area, the gas monitoring equipment, the gas sampling procedures, and methodology. In addition, factors that may influence field results are described for future consideration.

2.1 Study Area

The City of Vancouver Environmental Protection Branch staff inspected buildings within the study area bounded by:

- Cambie Street in the east;
- Burrard Street in the west;
- Lamey's Mill Road, Moberly Road and Commodore Street to the south; and
- False Creek foreshore to the north.

Figure 1-1 illustrates the subject area, and indicates the buildings that were inspected by the City of Vancouver for explosive gases. This included all buildings (commercial and residential), and all below-grade or slab-on-grade structures with the exception of:

- the Alder Bay Co-operative Housing complex (Buildings 8 through 15) done by others, and
- underground utilities on public and private land.

In addition to the City of Vancouver testing program, other agencies have also investigated the September 14 explosion. BC Research Inc. prepared a report entitled "Investigation of Explosion in Electrical Vault: Alder Bay Co-op". Consultants for the Alder Bay Co-operative Housing also completed a survey specifically for the area around the housing co-op.

Also, the area occupied by the City of Vancouver Works Yard east of the Cambie Street Bridge was undergoing an assessment by others for the City of Vancouver.

2.2 Test Equipment

Building spaces were tested for the presence and concentrations of methane and hydrogen sulphide (H_2S) gases using an AIM Logic 3250 gas detector and a Gastec Model 801 Gas Sampling Pump.

The Aim Logic gas detector is a portable instrument that has three sensors on the detector: a multigas sensor, a carbon monoxide/hydrogen sulphide sensor and an oxygen sensor. The multigas sensor is capable of individually measuring the concentration of 28 industrial combustible gases. It had recently been serviced and calibrated by the AIM Safety Company Inc, Delta, BC (August 26, 1998, just 22 days prior to the start of the inspection program). A new multigas sensor head is accurate to $\pm 10\%$ for methane gas at room temperature; and the City of Vancouver has confirmed that the sensor was purchased in September 1998. Sensors older than one year may only provide $\pm 30\%$ accuracy. The range of the instrument is 0 to 100% LEL for all precalibrated gases measured by the instrument. The concentration of methane gas is shown as a percentage of the lower explosive limit (%LEL). The presence of CO is known to interfere with the Aim Logic gas detector's ability to measure H_2S , which can result in potentially artificially high measurements of H_2S .

The Gastec Model 801 Sampling Pump measures the concentration of H_2S in air using a colourimetric detection tube, specifically formulated to measure the concentration of H_2S . A piston is used to draw air into a colour-indicating detection tube, where H_2S reacts with a chemical coating on a foam strip and *changes colour in proportion to the H_2S concentration*. Since this method relies on the proper quantity of air being drawn into the tube, the sampler must be without leaks. Checking the instrument for air-tightness before making H_2S measurements decreases the likelihood of inaccuracies. The detection tubes used with the Gastec 801 were purchased new just for this project.

2.3 Testing Methodology

There were three City teams involved in the gas testing program. The number of gas measurements recorded by City staff varied from building to building; however, the choice of sampling location from building to building is consistent, as were sampling methods.

Before entering each building, the AIM combustible gas detector was allowed to warm-up and "blank" samples taken outside in fresh air to establish background levels of methane, oxygen, and H_2S . Combustible gases were measured at *mid-air* and *point-of-entry* locations. *Mid-air* concentrations were measured as the technician was walking through building spaces. *Point-of-entry* concentrations were obtained by inserting the sensor directly into or next to possible *point(s)-of-entry*, such as cracks in the walls or floor, piping and/or electrical conduits. Blank samples of fresh air were not necessarily taken between consecutive measurements, since this is not a requirement for the instrument.

When H₂S was detected with the AIM Logic gas detector 3250, the technicians would use the Gastec Model 801 Sampling Pump to obtain a second measurement if they could smell H₂S. If they could not detect an H₂S odour, the original H₂S measurement was attributed to interference from CO, and was disregarded.

2.4 Discussion

Point-of-Entry Sampling

Gas can travel through concrete walls and flooring where there are open pathways. In concrete basements and underground structures, such pathways are typically found near floor drains, sumps, electrical conduits, cracks, vents, etc. If there exists a pressure differential between the adjacent soil and the building spaces, these locations are potential *point(s)-of-entry* of explosive gases into buildings. Explosive gases detected at *point(s)-of-entry* may indicate that there is an ingress of gases into the building, which could accumulate to dangerous concentrations if there are enclosed areas of the building where the ambient air is not well ventilated with fresh air.

Soil gases entering a building through an opening in the foundation such as a crack or a drain are most concentrated at the *point-of-entry* since the gases have not yet mixed with ambient air in the building. Factors affecting the resulting *mid-air* concentration are:

- the concentration of gas at the *point-of-entry*,
- the flow of gas at the *point-of-entry*,
- the flow of fresh air into the room, and
- the size of the room.

For example, a high concentration of methane gas is most likely to occur where there is a high concentration of methane and a significant flow of gas entering the room at the *point-of-entry*, and an inadequate supply of fresh air ventilation.

The *point-of-entry* concentration is also indicative of the soil gas concentration since the flux of methane is likely from the soil into the building.

Mid-Air Sampling

City technicians indicated that the gas detector was used to sample ambient air continuously during their building inspections. Specific *mid-air* measurements were taken at a variety of locations and heights as the inspectors approached *point-of-entry* sampling points. In Appendix C of the City's vapour gas survey, *mid-air* measurements are those without an "x" in any of the *point-of-entry* boxes.

Mid-air sampling of indoor ambient air is the most important measurement for assessing the migration and accumulation of a gas such as methane. Mid-air detection and measurements are preferably taken 1.5m off the floor. Checking the mid-air concentration of methane at both the interior and exterior walls of enclosed spaces can indicate whether the source of methane is inside or outside that space.

Soil Gas Testing

Soil gas testing was not included in the City's vapour gas survey. Based on the information provided, there appears to be no soil gas monitoring probes within the subject area. The City's gas survey report indicates that methane gas was measured in some buildings but it remains undetermined whether the source of the methane was from sewer or from soil gases.

The presence of soil gas is best determined by installing gas monitoring boreholes, or wells. Permanent wells consist of a perforated plastic casing adjacent to the strata, with gas withdrawal tubes permanently installed within the casing. To obtain more representative data, multiple point monitoring wells can be installed, where discrete sampling probes are placed at set depth intervals within the wells. Soil gas monitoring probes would provide an indication of soil gas concentrations and pressures adjacent to buildings, which would assist in the evaluation of risks to buildings in the subject area.

Atmospheric and Weather Conditions

Changes in ambient temperature and barometric pressure affect the rate at which gases such as methane migrate through the soil. Increases in ambient temperature typically enhance the diffusion of the gas through the soil, and results in increased rates of gas migration.

Changes in barometric pressure can cause release of underground methane to the atmosphere. A decrease in barometric pressure increases the pressure differential between the soil and the atmosphere and thereby increases methane release. In general, as the vertical migration of methane increases, the lateral movement of the gas is correspondingly reduced. Conversely, increased barometric pressure will, in general, slow the vertical migration. This could cause either increased lateral migration or accumulation of methane in the soil. In cases where the soils surrounding a site are highly permeable in relation to the covering soil, a decrease in barometric pressure will increase lateral migration.

It is conceivable that methane concentrations in open-air parking garages could be affected by atmospheric conditions. For example, a low barometric pressure could potentially increase the flux of gas into the building. If it is raining, the flux of gas out of the soil could increase due to low pressures and filling of the soil pores with water.

Although City staff did not record any atmospheric or weather conditions during this testing program, it would be advisable to include this information in future gas monitoring or inspection programs. Atmospheric conditions, such as ambient temperature, barometric pressure and weather conditions, taken simultaneously with methane measurements would assist in the interpretation of methane gas concentration changes. Information regarding ventilation systems in the tested areas (including whether it is on/off, positive/negative

pressure, cycled/continuous) should also be recorded. The presence of a ventilation system is noted in the gas survey document, however it is preferable to test these areas with the ventilation system both on and off.

Oxygen and Carbon Monoxide Readings

As part of the survey, oxygen and carbon monoxide concentrations were monitored continuously, though the readings were not recorded. At no time was there any oxygen concentration readings below 20% by volume or carbon monoxide readings that would indicate oxygen deficiency. Oxygen and carbon monoxide concentrations should be taken and recorded to identify and warn of any oxygen deficient situations.

Quality Assurance

During the course of the gas vapour study, City staff took several measurements of 100% LEL methane. In one such case, a Tedlar bag sample of the gas was taken to a laboratory for independent verification. While collecting the sample, a field reading of 74% LEL was measured at the sample point. The methane concentration, as measured by laboratory equipment and methods, was 68%LEL. Taking into consideration the sampling method, any dilution effects, and concentration variations while sampling, it appears that the field measurements are reasonably accurate.

The gas vapour survey report does not indicate the frequency in which this QA/QC procedure was carried out. As a minimum, one field sample should be confirmed with a laboratory measurement each time the instrument is calibrated.

The gas vapour survey report also does not indicate or include any documentation that shows how often the instrument was calibrated during the survey. City staff have indicated that the Aim Logic Gas detector was calibrated a number of times throughout the course of the survey and that records do exist. The instrument should be calibrated prior to each outing, or as recommended by the manufacturer. Also, records should be taken that include the date of calibration, concentration and type of calibration gas, and lot number.

Standardized data sheets were used in the gas vapour survey report to present the field data. Reporting of additional information, including supposed reasons for high methane measurements, and existing gas mitigation measures were also noted on these standardized data sheets.

SECTION 3 EXISTING GUIDELINES, CRITERIA AND STANDARDS

CG&S has performed a search to identify guidelines, criteria, standards, and regulations pertaining to methane and H₂S gas in buildings using the following research tools:

- Internet search
- Intranet search (CH2M Hill internal network of databases)
- Journal review
- Telephone and email surveys
- Government documents
- Case studies
- Literature review of guidelines, criteria and standards (see Appendix B: References, and Appendix C: Reviewed Literature for detailed list).

This research effort contacted individuals in the following organizations:

- CH2M Gore & Storrie Ltd.
- CH2M Hill Ltd.
- Ontario Ministry of the Environment
- Municipal Solid Waste Divisions
- Fire Departments
- Fire Prevention
- Canadian Standards Association (CSA)
- National Fire Code
- United States National Fire Protection Association (US NFPA)
- Occupational Safety and Health Association (OSHA)
- British Columbia Workers' Compensation Board (BCWCB)
- British Columbia Ministry of Energy and Mines
- Canada Mortgage and Housing Corporation (CMHC)
- New Jersey Department of Environmental Protection
- Air Quality Branches
- Policy Development
- Public Health Departments
- Municipal Building Inspection.

A detailed list of individuals contacted is found in Appendix D.

The search resulted in a compilation of guidelines, criteria and standards found in other jurisdictions to regulate levels of explosive gases. The end goal of this review process is to:

- identify common elements found in the guidelines, criteria and standards governing the presence of explosive gases in buildings, and
- use these elements to propose explosive gas action-level criteria to the City of Vancouver.

3.1 Existing, Guidelines, Criteria and Standards for Methane Gas Concentrations

Most of the literature of relevance that was collected for this review relates to methane gas generated in landfills. The False Creek situation is similar to landfill gas migration but in this case, biogas was generated from marshland. Although no landfills are known to exist on the south shore of False Creek, the trigger/alarm concentrations and their associated actions obtained through this review are valid for situations where methane gas exists. Also there are no specific references to structures such as parking garages or similar underground facilities, but the documents identified provide a reasonable basis for identifying applicable standards.

Action level values obtained in this review normally pertain to buildings (residential, commercial and industrial) and are discussed in terms of "landfill-generated" methane gas. Within this context, methane concentrations are frequently discussed using the terms: *off-site* and *on-site*, referring to gas concentrations on either side of the landfill property boundary.

Efforts to determine the existence and extent of a potential methane gas risk to a building frequently involves methane measurements in three types of locations:

- *mid-air*,
- *point-of-entry* locations, and
- *soil gases*.

These locations are used in this report for evaluation of the City's gas vapour testing program, for review of combustible gas literature, and for the proposed action level criteria in Section 4. Values for allowable methane concentrations identified in this section are from guidelines, criteria or standards developed in other jurisdictions.

In addition, there are two case studies to be discussed: one involving action level criteria developed in response to methane migrating from a landfill, and the other concerning methane gas which was causing oxygen deficiency in nearby homes where occupants were enduring nausea and weakness.

Mid-Air Methane

Guidelines, criteria and standards obtained for *mid-air* methane concentrations are summarized in Table 3-1. Although all concentration values are for *mid-air* methane, some are labeled as "landfill-generated" methane. Also presented is a listing of the source documents. Jurisdictions from which methane values were obtained in terms of landfill generated methane included the following:

- Province of British Columbia,
- Province of Ontario,
- Province of Quebec,
- State of Washington,
- State of New Jersey, and
- United States Environmental Protection Agency (US EPA).

British Columbia's Landfill Criteria for Municipal Solid Waste stipulates that "landfill-generated" methane should not exceed 25% LEL (12,500 ppmv) by volume in any *on-site* or *off-site* buildings. The required action is the implementation of a monitoring program. Regulations in the Province of Quebec are essentially the same as those in B.C.

The Province of Ontario has strict standards for "landfill-generated" methane in buildings outside landfill boundaries. Zero methane is allowed in *off-site* buildings, or in the soils immediately adjacent to a building's foundations. If methane is detected, a monitoring program must be implemented, and when methane exceeds 20% LEL, gas control measures are required.

The US EPA requires that quarterly monitoring be performed in any *on-site* landfill structure whether or not any gas is ever found and the owner must take actions to prevent the action levels from occurring. If the action levels are exceeded, the owner must take corrective action, but specific actions are not specified.

The State of New Jersey requires that an active venting system be installed when methane exceeds 25% LEL. Washington State has a regulation that limits allowable methane in structures to 0.2% LEL (100 ppmv), although there were no prescribed actions if this level was exceeded.

The US NFPA and the City of Winnipeg's methane gas criteria do not stipulate whether the methane is "landfill-generated". The City of Winnipeg stipulates that a building shall be evacuated if the *mid-air* methane concentration exceed 5% LEL. The US NFPA uses an evacuation limit of 10% LEL (5,000 ppmv) in *mid-air*. The City of Vancouver Fire Department uses an evacuation limit of 20% LEL in *mid-air*.

A general telephone survey indicated a general consensus that some form of appropriate action be required for *mid-air* concentrations of methane gas of 20-25% LEL.

Table 3-1: STANDARDS FOR METHANE GAS IN MID AIR			
Jurisdiction	Methane Concentration Limit	Required Action if Limit Exceeded	Regulation/Guideline
VALUES IN TERMS OF LANDFILL GENERATED METHANE GAS			
Ontario	Zero in any off-site building or in the area immediately outside the foundation of the building	Monitoring program required to record and monitor methane concentrations; if methane concentration exceeds 1% by volume, methane gas migration control measures must be put in place	New Standards for Landfill Sites, Proposed Regulatory Standards for New Landfilling Sites Accepting Non-Hazardous Waste (June, 1996)
British Columbia	12,500 ppm (25% LEL) in any on- or off-site building	Monitoring program must be prepared and approved by BC Environment authorities	Landfill Criteria for Municipal Solid Waste (June, 1993)
Quebec	12,500 ppm (25% LEL) in air in buildings on or near a landfill	Monitoring program required to record and monitor methane concentrations; if methane concentration exceeds 1% by volume (20% LEL), methane gas migration control measures must be put in place	Projet de reglement sur les dechets solides, version technique (March 1994)
US EPA	12,500 ppm (25% LEL) in any on-site structure	Must ensure monitoring program is implemented and performed quarterly	Resource Conservation and Recovery Act (RCRA), Subtitle D (October, 1991)
New Jersey	12,500 (25% LEL) inside buildings	Induced draft or active venting system must be installed	Solid and Hazardous Waste Management Regulations, Title 7
Washington	100 ppm (0.2% LEL) in off-site structures		Criteria for Municipal Solid Waste Landfills, WAC Chapter 173-351
VALUES IN TERMS OF METHANE GENERATED BY ANY SOURCE			
City of Winnipeg	2,500 ppm (5% LEL) mid-air level in a portion of a building	Alarm situation – advise occupants of the building to vacate the premises; provide extra ventilation; shut off sources of ignition; call 911; if the conditions cannot be alleviated, the building will remain vacated. If the situation is stabilized, the City will test the premises daily until long-term protection is provided.	Standards and Guidelines for the Mitigation of Methane Gas at Buildings and Utilities (May 1997)
US NFPA	5,000 ppm (10% LEL) inside buildings	Evacuation of facility	NFPA 820

Point-of-Entry Methane

The City of Winnipeg is the only jurisdiction whose standards differentiated between *mid-air* and *point-of-entry* methane concentrations. A "*point-source*" concentration of 20% LEL requires mitigation if the condition is "consistently" measured. A "*point-source*" is defined as a floor crack, floor joint, floor drain, column base, utility access penetration, base grade crack, or pile base, and "consistently" is defined as the majority of monthly readings above 20% LEL (Ref. 1).

Soil Gas Methane Concentrations

Transport of sub surface gas occurs by advection (flux due to a pressure gradient) and diffusion (flux due to a concentration gradient). Normally, subsurface gas transport is by advection and diffusion is negligible. The make-up of soil gas is based on several factors including:

- Soil conditions, such as permeability and moisture content
- Presence of man-made pathways, such as sewers
- Atmospheric conditions, such as barometric pressure, wind, rain, and temperature, and
- Quantity of gas produced at the source and the distance from the source.

If the pressure of soil gases adjacent to a foundation wall is higher than the indoor air pressure, then there will be a flux of gas into the building. The pressure differential driving this flux is dependent upon:

- Soil type
- Soil conditions
- Atmospheric conditions
- Soil gas pressure, and
- Indoor air pressure.

Several jurisdictions have regulations regarding soil gas methane concentrations within the context of a landfill. In British Columbia landfill criteria require that combustible gas concentrations in soils not exceed the LEL at the property boundary (Ref. 2).

In Ontario, regulations dictate sub-surface migration from landfills by specifying maximum levels of methane permitted. Sub-surface methane must:

- not exceed the LEL at the property boundary,

- not exceed 20% LEL immediately outside the foundation of an on-site building accessed by persons or containing electrical equipment or a potential source of ignition,
- be zero immediately outside the foundation of an off-site building accessed by persons or containing electrical equipment or a potential source of ignition (Ref. 3).

The Washington Administrative Code states that the concentration of methane cannot exceed the LEL at or beyond the landfill property boundary (Ref. 4).

Case Study - Midway Landfill, Seattle, Washington

In 1985 there was an explosion in a building near the Midway Landfill near Seattle, Washington. Investigators found elevated concentrations of methane in houses near the landfill and it was concluded that methane gas was migrating subsurface from the landfill property. The explosion prompted the Seattle-King County Department of Public Health to put in place action level criteria for affected homes. The action level criteria are presented in Table 3-2. Additional prescribed actions include the following:

- Homes requiring evacuation can only be reoccupied when *mid-air* methane concentrations are below 1,000 ppmv for a minimum of two weeks. During this period, methane must be measured on at least two separate occurrences of a barometric pressure below 29.8 inches of mercury.
- The Department of Public Health stipulates that homes shall continue to be monitored according to the action levels in Table 3-2 until the highest concentration in *mid-air* remains below 100 ppmv for a two week period (including the requirement for two occurrences of a barometric pressure below 29.8 inches of mercury). This is consistent with Washington State criteria in Table 3-1 which limits methane in off-site structures to 0.2% LEL (100 ppmv).

Although there are elements of the Table 3-2 criteria that are more conservative than other guidelines, the evacuation limit (a *mid-air* reading of 5,000 ppmv (10% LEL) is consistent with that of the US NFPA.

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TABLE 3-2: ACTION LEVEL CRITERIA FOR MIDWAY LANDFILL	
Methane Gas Concentration (by volume)	Action
0 - 50 ppmv	Normal Conditions
50 - 100 ppmv	Monitor as frequently as staff size permits
100 - 500 ppmv	Monitor daily
exceeds 500 ppmv	Monitor daily, seal cracks, request owner to ventilate
exceeds 1000 ppmv	Verify with second instrument and methane unit, seal cracks, install alarm and a fan, monitor daily, notify Health Department and Fire Department
exceeds 5,000 ppmv in atmosphere (<i>mid-air</i>)	Evacuate, call 911
exceeds 10,000 ppmv in wall or small confined spaces	Evacuate, call 911
exceeds 40, 000 ppmv for point source	Evacuate, call 911

Case Study - Cape Breton, Nova Scotia

Repeated complaints of weakness and nausea were reported from residents of a single household.

Investigators found that the building had been constructed over old coal mine workings. The sanitary sewer, instead of being connected to the city network, was connected to the former mine system through a hole in the crawl space. Gas measurements at the *point-of-entry* in the hole were:

- O₂ 16%
- CO₂ 2.75%
- CH₄ 5%
- Explosive meter reading 100%.

Mid-air measurements inside the house were :

- O₂ 20%
- CO₂ 1.2%
- CH₄ 3%

Following evacuation, the problem was remedied with a proper connection to the municipal sanitary sewerage system, and sealing the foundation opening. It was concluded that the nausea and weakness were symptoms of oxygen deficiency.

3.2 Existing Standards for Hydrogen Sulphide (H₂S) Concentrations

The British Columbia Workers Compensation Board Occupational Health and Safety Regulations (effective April 1998), has an H₂S ceiling exposure limit of no greater than 10 ppmv. The ceiling limit is the concentration of H₂S that may not be exceeded at any time during the work period.

Previous WCB regulations allowed 10 ppmv permissible concentration for an eight hour period, and 15 ppmv permissible concentration for a 15 minute limit.

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SECTION 4 PROPOSED ACTION LEVEL CRITERIA

Municipalities can meet their responsibility to protect residents by establishing policies and guidelines regarding hazardous gas concentrations. Strategies for establishing such guidelines are discussed in a 1993 Canada Mortgage and Housing Corporation (CMHC) publication entitled "Soil Gases and Housing - A Guide for Municipalities". This section contains proposed action level criteria for methane and discusses acceptable limits for hydrogen sulphide (H_2S).

4.1 Proposed Action Level Criteria for Methane Gas

Three precursors are required for a methane gas explosion: the presence of methane, the presence of oxygen, and an ignition source. The proposed action level criteria presumes that sufficient oxygen and an ignition source are present. The proposed action criteria are presented in Table 4-1; these are based on information from available criteria, guidelines, and standards. They are divided into *mid-air*, *point-of-entry*, and *soil gas* criteria.

Proposed Mid-Air Methane Action Levels

Mid-air methane concentrations depend on the rate of methane influx, and the rate that the methane is mixed and diluted with fresh air. For example, a specific influx of methane gas could accumulate in an enclosed space with poor ventilation to dangerous methane concentration levels, but may not accumulate to the dangerous levels in a high-ceilinged, open-air parking garage. Even a low concentration of methane in *mid-air* may indicate a significant influx of gas if the space is open and well ventilated.

1st Level Mid-Air - We propose that *mid-air* methane concentrations from 1% LEL to less than 10% LEL be the lowest action criterion for methane. This concentration is sufficient to indicate that methane is present above background levels. Methane background levels outside the buildings have been measured at zero percent methane by volume. The appropriate response action would include: taking a reading with a second instrument, identifying all potential points of entry, monitoring these points for methane levels and sealing the points of entry. If the gas is not entering the building from the outside, the interior source must be identified and corrective action taken. Existing ventilation systems should be checked to ensure they are operating as designed. Further monitoring (monthly) would be required to indicate whether methane concentrations are stable and/or returning to background concentrations.

2nd Level Mid-Air - *Mid-air* concentrations of methane from 10% LEL to less than 20% LEL is proposed as the next action level criterion. This was selected as a useful midpoint action level criterion. Measured concentrations in this range warrant the

required actions stated in the 1st level *mid-air* action level criterion plus the following: daily methane monitoring until methane levels decrease below 10% LEL and then implementing the 1st level *mid-air* actions, and ensuring that existing ventilation is operating as designed. Positive pressure, continuous ventilation may be required to reverse the direction of air flow through cracks and openings in the building space.

3rd Level Mid-Air - We propose that a methane concentration 20% LEL and greater in *mid-air* initiate an immediate evacuation of the building. This action level criterion is consistent with the City of Vancouver Fire Department's recommended evacuation limit of 20% LEL (10,000 ppmv). For a trigger concentration of 20% LEL, Table 4-1 provides the immediate required measures. These actions include: immediate building evacuation, calling 911, and confirming readings with a second instrument. If the second reading is less than 20% LEL, then the appropriate *mid-air* actions should be taken. If the second reading is 20% LEL or greater, ventilate the building with fresh air, locate points of methane gas entry using detection equipment, and proceed with point of entry action. The building should not be re-entered until source control and ventilation with fresh air have reduced the *mid-air* concentration of methane to less than 5% LEL (2,500 ppmv). When reentering the building, continuous monitoring of methane is required until future risk to building safety is eliminated. Although our research found that the City of Winnipeg uses a action level criterion of 5% LEL for evacuation, this may be overly conservative in comparison to the 20% LEL action level used by the City Fire Department.

Proposed Point-of-Entry Methane Action Levels

The City of Winnipeg and the King County Health Department in Washington State have both prescribed actions for elevated methane gas concentrations detected specifically at *point-of-entry* locations. The City of Winnipeg prescribes that consistent measurements exceeding 20% LEL at a *point-of-entry* requires mitigation. The King County Health Department states that a gas concentration at a point source containing in excess of 80% LEL (40,000 ppmv) requires immediate evacuation of the building.

For the City of Vancouver, we are proposing two action levels for methane gas detected at *point-of-entry* influx locations.

1st Level Point of Entry - We propose that methane concentrations from 10% LEL to less than 20% LEL be the 1st level *point-of-entry* action criterion for methane. This concentration is sufficient to indicate that methane is present, and has the potential to accumulate if the fresh air ventilation is inadequate. Proposed action includes: taking a reading with a second instrument; taking *mid-air* readings and actions; identifying and sealing all potential points of entry to stop the ingress of methane gas, and checking that P-traps for sumps and floor drains contain sufficient water to establish a proper seal against sewer gases. A monthly monitoring program at *mid-air* and *points of entry* must be carried out in the buildings until methane readings are zero for one year.

2nd Level Point of Entry - The second proposed level of action for a *point-of-entry* source is a concentration of 20% LEL or greater, which may indicate a significant influx of methane gas from the adjacent soils. In this situation, it would be prudent to take readings from a second instrument to confirm the concentration and take *mid-air* readings. If *mid-air* methane concentrations exceed the action level criterion then the corresponding *mid-air* actions would be applicable. Other required actions include: ventilating the building in a safe manner, and identifying all potential points of entry and sealing these points of entry. Also, soil gas probes should be designed and installed at locations determined by a qualified professional engineer or geoscientist. A continuous monitoring program using a permanent methane gas analyzer in the building should be established until future risk to building safety is eliminated.

The basis for the proposed 20% LEL *point-of-entry* action level criterion is that methane gas can potentially accumulate at a small entry point, eventually creating an explosive mixture. As public safety is the primary concern for the City of Vancouver, a conservative approach is warranted until further investigations can be performed.

Proposed Soil Methane Action Levels

Two action level criteria are proposed:

1st Level Soil Gas - The first level action criterion is for any detectable methane concentration in the soil. If detected, monthly monitoring for pressure and methane concentration should be carried out until no gas is detected for one year.

2nd Level Soil Gas - The second level action criterion is dependent on the static pressure within the soil gas monitoring probe. The second level action criterion applies to methane concentrations 100% LEL or greater at pressures less than 1 inch of water column (W.C.), and for concentrations 10% LEL or greater if pressure is greater than 1 inch W.C.. If these concentrations are exceeded, action must be taken to remove the gas from the soil. A system to remove the gas from the soil should be designed by a qualified professional.

For new buildings constructed on the south shore of False Creek, testing requirements should be established, as well as soil gas criteria.

4.2 Proposed Action Level Criteria for H₂S Gas

Mitigative action should be carried out if the H₂S *mid-air* concentration is confirmed to be greater than 10 ppmv (BC WCB ceiling exposure limit). Proposed action includes: identifying the source of H₂S, sealing the *point(s)-of-entry* to stop the ingress of H₂S, and checking that P-drains for sumps and floor drains contain sufficient water to establish a proper seal against sewer gases. Further actions, such as improved ventilation with fresh air, and installation of H₂S monitoring equipment, may be required for persistent H₂S problems.

Table 4-1: Action Level Criteria for Methane Gas in Existing Buildings

Action Level	Methane Concentration	Required Action
Mid Air		
1 st Level <i>Mid-Air (MA)</i>	1% to less than 10% LEL (500 ppmv to less than 5,000 ppmv)	Take readings with a second detector to confirm methane concentration. If second reading is less than 1%LEL, take a third reading in 10 minutes. If third reading is less than 1%LEL, no action is required. If two readings are within 1 st Level MA. action level range, then: • Ensure that any existing ventilation systems are operating as designed. • Identify all potential points of entry and monitor these for methane levels. Proceed to compare point-of-entry (PoE) reading with PoE action level criteria. Take indicated point of entry actions, based on concentrations found. • Determine if the gas is from interior source or is sewer gas, and take corrective action. • Establish monthly monitoring at mid-air and points of entry (cracks, vents, sumps etc.). Discontinue if methane readings are zero for one year.
2 nd Level <i>Mid-Air (MA)</i>	10% to less than 20% LEL (5,000 ppmv to 10,000 ppmv)	Take readings with a second detector to confirm methane concentration. If second reading is less than 10%LEL, take a third reading in 10 minutes. If third reading is less than 10%LEL, go to 1 st Level MA criteria. If two readings are within 2 nd Level MA action level range, then: • Ensure that any existing ventilation systems are operating as designed. • Identify all potential points of entry and monitor these for methane levels. Proceed to compare point-of-entry (PoE) reading with PoE action level criteria. Take indicated point of entry actions, based on concentrations found. • Determine if the gas is from interior source or is sewer gas and take corrective action. • Establish daily monitoring until level decreases below 10% LEL and go to 1st level MA required actions.
3 rd Level <i>Mid-Air (MA)</i>	20% LEL (10,000 ppmv) and greater	Evacuate building immediately/Call 911. Take readings with a second instrument to confirm methane concentration. If second reading is less than 20%LEL, take a third reading in 10 minutes. If third reading is less than 20%LEL, go to 2 nd Level MA criteria. If two readings are within 3 rd Level MA action level range, then: take immediate mitigation measures: • Ventilate building in a safe manner. Provide positive static pressure to structure to the extent practicable, use HVAC to maintain if possible. • Premises can be re-entered only when situation is deemed safe [i.e. when levels less than 5% LEL (2,500 ppmv) methane and source is under control]. • Identify all potential points of entry and monitor these for methane levels. Proceed to compare point-of-entry (PoE) reading with PoE action level criteria. Take indicated point of entry actions, based on concentrations found. • Determine if the gas is from interior source or is sewer gas and take corrective action. • Establish a continuous monitoring program until future risk to building safety is eliminated.

Table 4-1: Action Level Criteria for Methane Gas in Existing Buildings		
Action Level	Methane Concentration	Required Action
Point of Entry		
1 st Level <i>Point-of-Entry (PoE)</i>	10% to less than 20% LEL (5,000 ppmv to 10,000 ppmv)	Take readings with a second instrument to confirm concentration. If second reading is less than 10%LEL, take a third reading in 10 minutes. If third reading is less than 10%LEL, no PoE action is required and return to mid air action level criteria. If two readings are within 1st Level PoE action level range, then: • Ensure that any existing ventilation systems are operating as designed. • Identify all potential points of entry, test them for methane levels and seal the points of entry. • Determine if gas is from interior source or is sewer gas and take corrective measures. • If gas is not sewer gas, take mid-air readings and take strictest indicated actions based on mid-air and PoE concentrations measured. • If not sewer gas, establish monthly monitoring at mid-air and points of entry (cracks, vents, sumps etc.). Discontinue if readings are zero for one year.
2 nd Level <i>Point-of Entry (PoE)</i>	20% LEL (10,000 ppmv) and greater	Take readings with a second instrument to confirm concentration. If second reading is less than 20%LEL, take a third reading in 10 minutes. If third reading is less than 20%LEL, go to 1st Level PoE action level criteria. If two readings are within 3rd Level PoE action level range, then: • Ventilate building in a safe manner. Provide positive static pressure to structure to the extent practicable, use HVAC to maintain if possible. • Identify all potential points of entry, test them for methane levels and seal the points of entry. • Determine if gas is from interior source or is sewer gas and take corrective action. • If gas is not sewer gas, take mid-air readings and take indicated actions based on mid-air and PoE concentrations measured. • If gas is not sewer gas and is not from inside the building, install soil gas monitoring probes adjacent to the building and monitor them for methane and pressure. Gas probe locations, design and monitoring program should be determined by a professional engineer or geoscientist experienced in soil gas investigations. Gas probe locations and design should take into account the specific design of the building foundation and properties of adjacent soils. Take corrective actions as determined by the results of the gas probe monitoring program. • Establish a continuous monitoring program until future risk to building safety is eliminated.

Table 4-1: Action Level Criteria for Methane Gas in Existing Buildings

Action Level	Methane Concentration	Required Action
Soil Gas		
1 st Level Soil Gas	Any detectable	Monthly monitoring for pressure and methane – continue until no gas detected for one year.
2 nd Level Soil Gas	100% LEL (50,000 ppmv) or greater if pressure less than 1 in. WC. or 10% LEL (5,000 ppmv) or greater if pressure greater than 1 in. WC.	Take action to remove gas from soil. System to remove gas from soil should be designed by a professional engineer or geoscientist experienced in soil gas investigations. Design should take into account the specific design of the building foundation and properties of adjacent soils.

SECTION 5 EVALUATION OF RISKS FOR SOUTH FALSE CREEK SUBJECT AREA

5.2 Application of Action Level Criteria

The following is a summary of buildings where the City of Vancouver measured methane and H₂S concentrations during the gas vapour survey conducted in September 1998 that exceed the action level criteria developed in Section 4. Figure 1-1 shows the location of these buildings on the south shore of False Creek.

1st Level Mid-Air Exceedences (1% to less than 10% LEL)

Buildings #40, west side of #41
Address: 721 Millyard

A *mid-air* reading of 1% LEL *mid-air* methane concentration was measured in the common crawl space under Buildings #40 and #41. The presence or configuration of a ventilation system serving this crawl space has not been confirmed. There is no record of a ventilation unit near the area of concern. The 1st Level *mid-air* required action would apply to these buildings.

Buildings #70, #71, #72 and #73
Address: 1530 Mariner Walk
1508 Mariner Walk
1515 West 2nd Avenue
1505 West 2nd Avenue

A *mid-air* methane concentration of 1% LEL was detected in a boiler room (Building #70), garbage room (Building #71), electrical vault room and catch basins (Building #72), and elevator machine and sprinkler rooms (Building #73). The 1st Level *Mid-Air* action criterion would apply.

2nd Level Point-of-Entry Exceedences (20% LEL or greater)

Western Section of Building #46
Address: 673 Moberly Road

Methane was detected at a concentration of 1% LEL *mid-air* in a locker room in the above location. Further investigation yielded a *point-of-entry* methane concentration of 76% LEL in a floor drain of the locker room. After the floor drain was filled with water, no further methane was detected.

On a subsequent visit approximately two months later, the *mid-air* methane was measured at 1% LEL in the locker room, and the *point-of-entry* methane concentration at the floor drain was 50% LEL, and was observed to fluctuate from 0% to 20% LEL for a period of several minutes. 2nd Level *Point-of-Entry* action level criterion would classify this as an area of concern.

Building #53

Address: 518 Moberly Road

A *point of entry* methane concentration of 100% LEL was detected in a catch basin. City staff noticed at this time, that the walls of the catch basin were in a deteriorated condition and there was grout missing around the outlet pipe. After the catch basin was repaired, *point-of-entry* concentrations of 1% LEL were detected on a subsequent visit. The initial measurements at this location classified this catch basin as a 2nd level *Point-of-Entry* action level criterion whereas none of the action level criteria would apply based on the second reading taken after the repairs. A third reading should be taken at this location for confirmation and evaluated against the action level criteria.

Buildings #58, #59 (common underground parking) and Building #84

*Address: 1869 Spyglass Place
1859 Spyglass Place
525 Wheelhouse Square*

In the underground parking garages of these three buildings, the City report refers to "floor vents", most of which are capped. Two vents in Building #59 and one vent in Building #84 did not have caps. *Point-of-entry* methane concentrations in several of these floor vents when uncapped ranged from 0% to 100% LEL over consecutive days. Over this same period, *mid-air* concentrations of 1% LEL and 4% LEL were observed in parts of the parking areas of Buildings #58 and #59, respectively. This falls into the 2nd level *Point-of-Entry* action level criterion.

At this time it is unclear as to how the "venting system" was designed to operate, and it is suggested design record drawings be obtained for review. The vents should remain capped and sealed (until further information is provided), and a protective barrier constructed around them to avoid breakage.

H₂S Exceedences

Building #63

Address: 1551 Mariner Walk

An H₂S concentration of 11.4 ppmv was detected in the work shop room, where paints and solvents are stored. The source of the H₂S is not known. The building's positive ventilation system was reportedly not functioning at the time due to annual maintenance being completed on the electrical system. Also, it is likely that cross sensitivity with carbon

monoxide played a role as the door to the workshop was open and vehicles were driving by at the time of sampling.

Building #58

Address: 1869 Spyglass Place

An H₂S concentration reading of 22.0 ppmv was taken from an uncapped vent. Building #58 is one of three buildings constructed with gas vent piping in the event a methane gas system was required later.

5.2 POTENTIAL RISKS

Potential Risk Due to the Presence of Methane

Although methane was not detected in some buildings during the gas vapour survey conducted by City of Vancouver in September 1998, or may have not exceeded the action level criteria presented in Section 4, there is the potential that methane could enter these buildings at a later date. For this reason a monitoring program has been recommended.

If no action is taken, there is a risk that methane could accumulate undetected to concentrations that could result in an explosion if the required elements (fuel, ignition, and a medium to support combustion) are present. Based on the results of the September gas vapour survey, sources of ignition were present in most of the building where methane was detected. These sources of ignition could be a pilot flame from a water heater or boiler, sparks from an elevator or an electrical transformer or sparks from the ignition of a car.

For those buildings in which methane exceeded the action level criteria, the recommended "Required Actions" should be carried out as described in Section 4.

Potential Risk Due to the Presence of H₂S

Two building locations have been identified in the September City Survey that exceed the BC WCB ceiling exposure limit for H₂S.

In Building #63, the high concentrations of H₂S may be due to the cross sensitivity with carbon monoxide and may not be the true concern. Instead the concentration levels of carbon monoxide, solvents and paints in the workshop room may pose a health risk if the ventilation system is not operated so as to reduce the levels of these materials below the respective ceiling exposure limits. The recommended action for the workshop room in Building #63, would be to install a door closer so that the workshop is not exposed to carbon monoxide from vehicles in the parking area, ensure that ventilation is provided when the room is occupied, and to limit the amount of paint and solvents stored in the room. During scheduled maintenance when workers are in the workshop room and the electrical power is turned off, a portable blower system should continuously ventilate the room.

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H₂S concentration at one of the gas vent pipe connections in Building #58 exceeded the BC WCB ceiling exposure limit when the cap was removed. Buildings #59 and #84 had lower H₂S concentration levels but potentially could have H₂S concentration levels that exceed the BC WCB ceiling exposure limit. If the "Required Action" stipulated in the recommended action level criteria is not taken and the gas venting systems in Buildings #58, #59 and #84 are not modified and activated, H₂S could accumulate within the vent piping to concentration levels above the ceiling exposure limit. If allowed to escape into the parking area the H₂S at this concentration level could pose a risk. A person may experience discomfort if repeatedly exposed day after day to H₂S concentrations above the ceiling exposure limit. The recommended action would be to: ventilate the affected area, locate and seal the source of the H₂S; install and activate the gas venting system; and install barriers to protect exposed piping within the parking area from damage.

SECTION 6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Evaluation of Gas Inspection Program

1. The City's "South Shore False Creek Gas Vapour Survey" was conducted in a thorough manner and was adequate in scope and coverage.
2. Measurements taken to date indicate that methane and H₂S gases have been detected in buildings at several locations in the South False Creek subject area.

Action Level Criteria

3. *Mid-air* (MA) concentrations of methane of 1% LEL (1st *Mid-Air* Action Level) were found in enclosed spaces in buildings #70, #72 and #73, and in a common crawl space under buildings #40 and #41.
4. *Point of Entry* readings exceeding 20% LEL (2nd *Point-of Entry* Action Level) were found in Buildings #46, #59, #58, #84, and #53. The PoE reading in Building #53 was at a catch basin. The high PoE methane concentrations in Buildings 58, #59 and #84 were detected when the caps were removed to collect PoE readings at underslab vent piping connections in the underground parking garages. The PoE reading in Building #46 was at a floor drain in a locker room.
5. A high (PoE) concentration of hydrogen sulphide (H₂S) exceeding the 10 ppmv WCB ceiling exposure limit was found in a workshop room in Building #63 where paints and solvents were being stored. Apparently at the time of sampling the ventilation fan was not operating due to an electrical system shutdown for annual maintenance.
6. Based on the action level criteria developed in Section 4, a risk of explosion could exist in some buildings (Buildings #58, 59, #84 and #46) in the subject area if the "Required Actions" indicated in the recommended section are not taken.

6.2 RECOMMENDATIONS

1. The recommendations provided in the City of Vancouver "South Shore False Creek Gas Vapour Survey", October 1998, should be carried out. These recommendations are:
 - All floor drains, catch basins and sumps should be maintained with a water seal and cleaned out on a regular basis.
 - Sumps require tight fitting lids and ventilation to prevent any build-up of gases. The outlet pipe from the sump must have a ninety degree elbow with a back water valve to maintain the water seal and to prevent any gases venting from the sewer system.
 - Many of the buildings in South False Creek have common parking facilities. Ventilation of underground parking facilities is required by the building code to prevent build-up of gases such as carbon monoxide. The ventilation systems must be maintained in operable conditions.
2. For future monitoring events, the calibration of the Aim Logic 3250 gas detector or any other field instrument used to detect methane should be performed using the method and frequency recommended by the manufacturer. Records should be kept on calibration dates and details. Also as a quality assurance and quality control measure, one field sample measurement should be confirmed with a laboratory measurement during the sampling event after the instrument has been calibrated or recalibrated.
3. The action level criteria developed in Section 4 of this report should be adopted and the recommended action level criteria used for future monitoring efforts.
4. A follow-up visit by the City to Buildings #58, #59, #84 and #53 is recommended to ensure that requested corrective action and repairs have been completed and to conduct a second set of mid-air and point-of-entry readings at these buildings. The methane readings should be compared to the recommended action level criteria and "Required Action" taken in accordance with the recommended action level criteria in order to reduce the potential risk to building safety.
5. Quarterly monitoring (every 3 months) should be conducted in all buildings located in the South False Creek study area (the area between Burrard Street to the west, Cambie Street to the east, Lamby Mills Road to the south and False Creek foreshore to the north). The next monitoring event should take place in March 1999. Those buildings that record zero methane readings for four consecutive monitoring events may be removed from the monitoring program. The same methodology used in the September 1998 South Shore False Creek Gas Vapour Survey should be used and methane readings should be compared to the recommended action level criteria. If the City undertakes this monitoring, the Owners should be advised of the readings. If building owners conduct this additional monitoring, they must submit the results to the City in a timely manner.

In either case, the Owner must complete the "Required Action" in accordance with the recommended action level criteria.

6. Determine and confirm high methane levels in Buildings #46, #53, #58, #59, #84, #70, #72, and #73 are due to sewer gas or from sources inside the building. In Building #46 (where methane concentration exceeded the 20% LEL/2nd Level PoE criterion), the source of methane may be due to sewer gas escaping from a floor drain with a dry P-trap. Methane exceeding the 20% LEL/2nd level PoE criterion in Building #53 could also be sewer gas from the catch basin that was later repaired. The source of methane (with a concentration exceeding the 20%LEL/2nd Level PoE criterion) in Building #58, #59 and #84 is unknown and may be soil gas. The source of methane (with a concentration of 1% LEL/1st Level Mid Air criterion) in Buildings #70, #72, and #73 is unknown and may be soil gas.
7. If sewer gas is determined to be the source, take necessary actions to prevent entry of sewer gas.
8. If it is determined that the combustible gas is not sewer gas or from a source inside the building, soil gas monitoring probes should be installed adjacent to buildings where 2nd level point-of-entry combustible gas exceedences have been found in enclosed spaces (Buildings #46, #53, #58, #59 and #84). The locations, design and monitoring program for these probes should be determined by a professional engineer or geoscientist with experience in soil gas monitoring. Furthermore, take soil gas readings and take corrective action according to the "Required Actions" if the methane concentrations exceed the "Soil Gas Action Levels". If the soil gas readings are below the action level concentration, continue with quarterly monitoring inside and outside the buildings.
9. If it is determined that the combustible gas in the underslab vent piping is not sewer gas or from a source inside the building and methane concentration levels within the vent piping are within the 2nd Level PoE methane concentration range, then the remaining parts of the underslab gas vent systems in Buildings #58, #59, and #84 should be installed. The gas venting system needs to be activated to remove any accumulation of methane gas around the building perimeter that could enter building penetrations and pose a risk to building safety. Underslab vent piping was initially installed in these buildings so that a gas venting system could be installed at a later date in the event methane and hydrogen sulphide levels pose a problem. The original building design drawings should be examined to: 1) identify how the underslab vent piping is to connect to the proposed gas venting system; 2) identify system configuration; and 3) identify how the intended gas venting system is meant to be operated. A qualified professional engineer should be consulted to design a system if no information is found on the original drawings.
10. A testing program should be carried out for the presence of explosive gases in utility and enclosed underground facilities throughout the study area, and particularly those facilities adjacent to the buildings where methane and hydrogen sulphide have been

found inside the building. Manholes, valve boxes, electrical and communication vaults and similar underground facilities should be tested.

11. All new buildings in the area should be evaluated by a professional engineer or geoscientist with experience in soil gas mitigation to determine the need for gas protection measures. These protective measures should be implemented as recommended by the qualified professionals.

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APPENDIX A

GLOSSARY OF TERMS

Appendix A Glossary of Terms

<i>Action Level Criteria</i>	Actions to be taken in response to a corresponding methane gas concentration.
<i>Advection</i>	Migration of molecules or ions in air or water as a result of their own random movements from a higher pressure zone to a lower pressure zone.
<i>Ambient air:</i>	That portion of the atmosphere external to buildings to which the general public has access.
<i>Anaerobic:</i>	The biological state of living and growing in the absence of oxygen.
<i>Barhole probe:</i>	A steel rod that is hammered into the soil to an approximate depth of one metre to allow sampling or measurement of soil vapours in the resulting void.
<i>Carbon dioxide (CO₂):</i>	One of the principle gases which comprises landfill gas. A greenhouse gas. Also the major product of hydrocarbon combustion.
<i>Combustible:</i>	Able to undergo a chemical reaction resulting in release of both heat and light; typically in combination with oxygen.
<i>Concentration:</i>	The relative fraction of one substance in another, normally expressed in mass percent, mass/volume, volume percent (% v/v) or as a percentage of the lower explosive limit (%LEL).
<i>Diffusion:</i>	Migration of molecules or ions in air or water as a result of their own random movements from a region of higher concentration to a region of lower concentration. Diffusion can occur in the absence of any bulk air or water movement.
<i>Domestic waste:</i>	Non-hazardous solid waste generated from households. Also referred to as residential waste or municipal solid waste (MSW). It does not include liquid or hazardous waste.

<i>Emissions:</i>	In air, pollutants in the form of gases or fine particles released into the atmosphere, usually from a stack.
<i>Explosion:</i>	Extremely rapid combustion of a compound resulting in an increase in volume and creation of pressures when enclosed.
<i>Explosive limit:</i>	The range of concentrations in air within which a compound is explosive. Methane forms explosive mixture when mixed with air in the range of 5 to 15 percent by volume. 5% by volume is referred to as the lower explosive limit (LEL) of methane in air. 15% by volume is referred to as the upper explosive limit (UEL) of methane in air.
<i>Flammable:</i>	Capable of being easily combustible and of burning quickly.
<i>Flux:</i>	The amount (mass or volume) of a substance flowing across a given area per unit time.
<i>Hydrogen Sulphide (H₂S):</i>	A colorless gas often characterized by its rotten egg smell. At high concentrations it is toxic to both the central nervous and respiratory systems.
<i>Ignite</i>	To start or cause to start to burn.
<i>Landfill gas (LFG):</i>	The mixture of gases (approximately one-half methane and one-half carbon dioxide) generated by the decomposition of putrescible organic wastes in a landfill. A landfill is a land-based disposal site for municipal solid waste. Waste is deposited under controlled conditions on land in a manner that minimizes environmental hazards, compacting the wastes to the smallest practical volume, and applying cover materials at the end of each operating day.
<i>LFG emission:</i>	The portion of LFG production that is released to the atmosphere (i.e. does not include LFG that is collected or migrates into the surrounding soil).
<i>Methane (CH₄):</i>	An odourless, colourless, non-poisonous gas which is explosive when mixed with air or oxygen in certain proportions. It is a greenhouse gas.

<i>Mid-Air</i>	Describes the sampling point within a building air space. Samples collected in ambient air approximately at a point 1.5 metres off the floor.
<i>Migration:</i>	LFG movement from one place to another, moving under diffusion and/or advection forces.
<i>Permeable:</i>	Permitting the flow of water or other liquids; the property of a solid material that allow fluids to flow through it.
<i>Point of entry:</i>	The point at which the gas enters into the building.
<i>PPB/ppb:</i>	Parts per billion (mass of substance (mg)/mass of solution (1,000kg).
<i>PPM/ppm:</i>	Parts per million (volume of substance (cm ³) per volume of air (m ³). Unit of measure for air and gas concentration on a volume basis.
<i>Soil Gas:</i>	Gases that migrate through the soil and enter buildings through cracks and other gaps in the structure. The most common soil gas contaminants are: hydrocarbons from petroleum products; landfill gas (primarily methane); methane from other sources (swamps, peat bogs and coal deposits); and other volatile organic compounds (VOCs).

APPENDIX B

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Appendix B

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APPENDIX C

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