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Ground-Gas Protection Process

John Naylor - TD GGS

East Midlands 5+1 Event

9th May 2019

Ground-Gas Protection Process

Presentation Content

1. Introduction and the Ground-Gas Hazard
2. Monitoring Techniques
3. Risk Assessment
4. Risk Management

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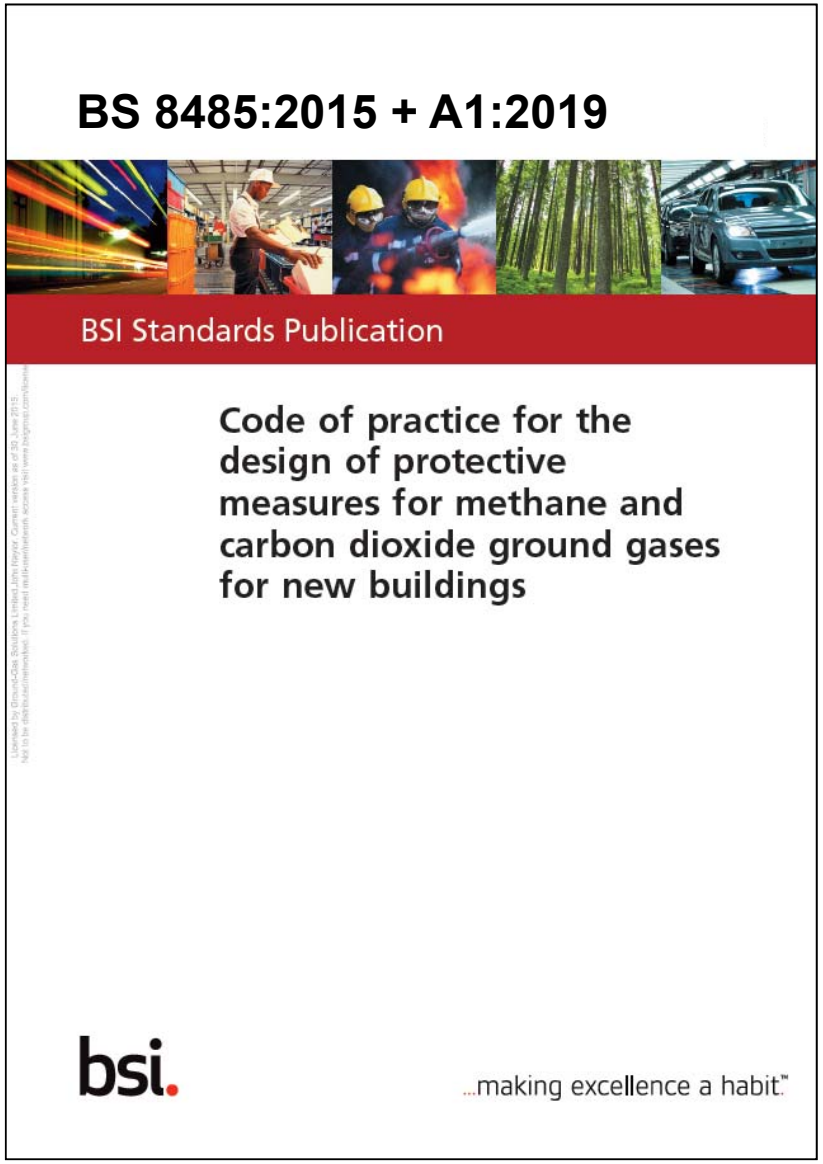

- Updated from the 2007 standard and first published June 2015
- Heavily used by industry (including regulators)
- Revised to: BS8485:2015+A1:2019
- Modified the Points Scoring System
- Amended some criteria for membranes

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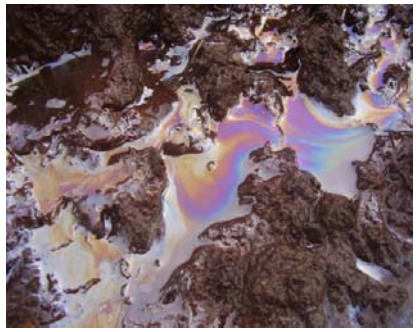
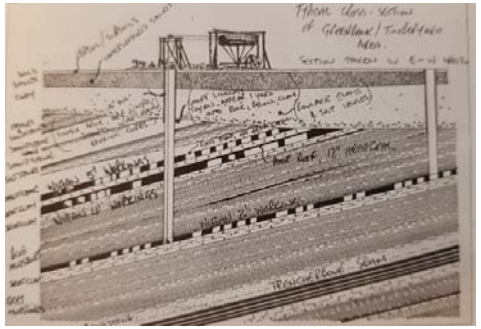
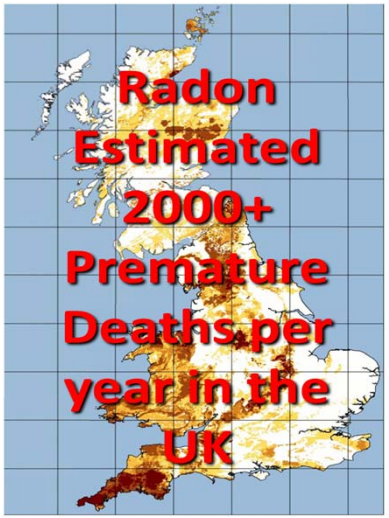
Ground-Gas Hazards







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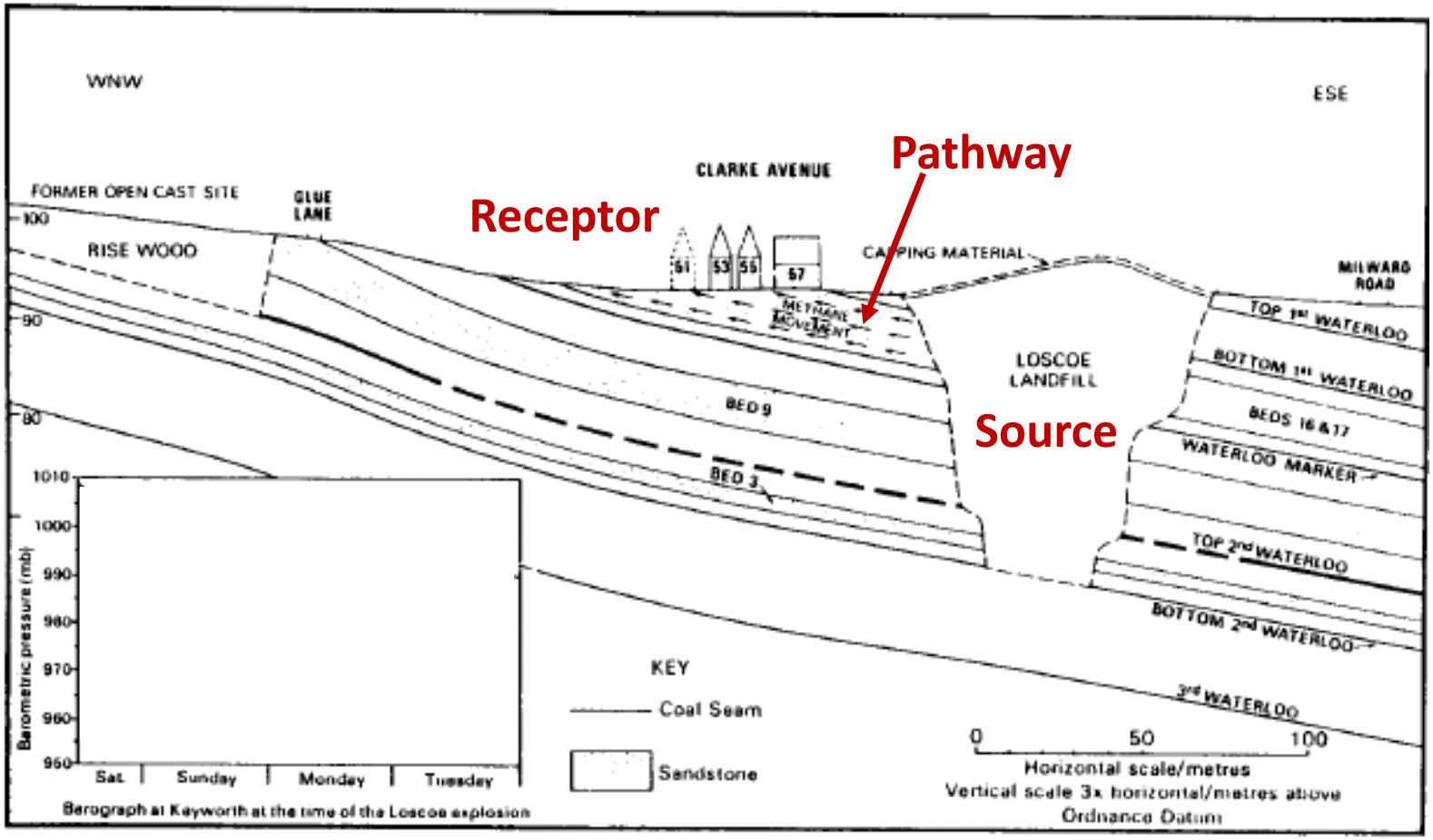
Loscoe Public Inquiry



CIRIA 130, 1995

Source - Pathway - Receptor

Driving mechanism

Pollutant Linkage

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Gorebridge Incident

- **New housing estate built in 2009**
- **7 Sept 2013 council tenants overcome by gas and taken to hospital. Families decanted to alternative accommodation**
- **2014 22 people sought medical help & IMT set up**
- **64 homes demolished in 2016**

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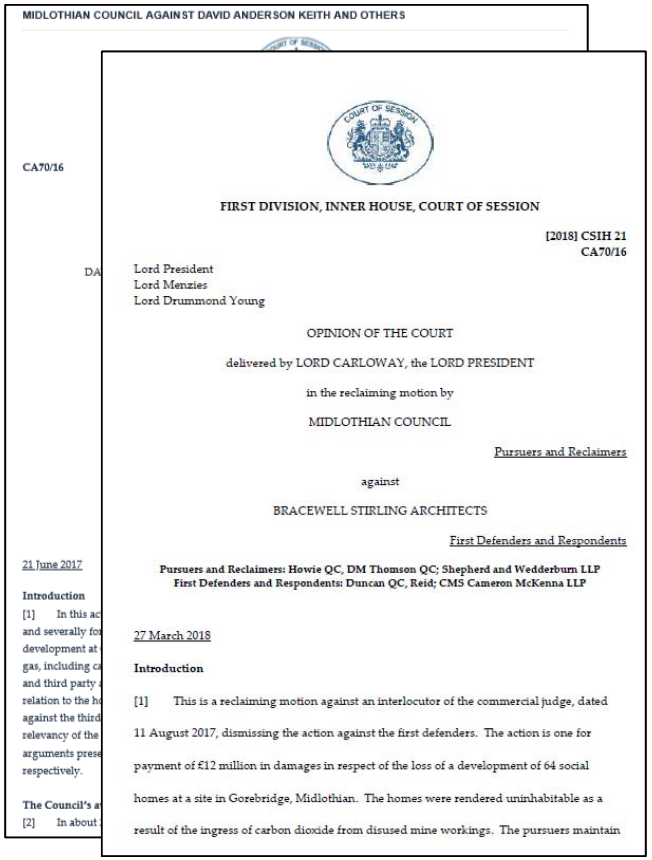
On-going Legal Cases

NHS Lothian

Carbon Dioxide Incident in Gorebridge, Midlothian, April 2014

Final Report of the Incident Management Team

November 2017



MIDLOTHIAN COUNCIL AGAINST DAVID ANDERSON KEITH AND OTHERS

CA70/16

FIRST DIVISION, INNER HOUSE, COURT OF SESSION

[2018] CSIH 21
CA70/16

Lord President
Lord Menzies
Lord Drummond Young

OPINION OF THE COURT

delivered by LORD CARLOWAY, the LORD PRESIDENT

in the reclaiming motion by

MIDLOTHIAN COUNCIL

Pursuers and Reclaimers

against

BRACEWELL STIRLING ARCHITECTS

First Defenders and Respondents

Pursuers and Reclaimers: Howie QC, DM Thomson QC; Shepherd and Wedderburn LLP
First Defenders and Respondents: Duncan QC, Reid; CMS Cameron McKenna LLP

27 March 2018

Introduction

[1] This is a reclaiming motion against an interlocutor of the commercial judge, dated 11 August 2017, dismissing the action against the first defenders. The action is one for payment of £12 million in damages in respect of the loss of a development of 64 social homes at a site in Gorebridge, Midlothian. The homes were rendered uninhabitable as a result of the ingress of carbon dioxide from disused mine workings. The pursuers maintain

21 June 2017

Introduction

Scottish Government appointed consultants to carry out a study into carbon dioxide hazards in former mining areas

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Ground-Gas Protection Process

Presentation Content

1. Introduction and the Ground-Gas Hazard
2. Monitoring Techniques
3. Risk Assessment
4. Risk Management

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Spot Monitoring

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Traditional Spot Monitoring

Exploratory hole	Time	Response zone range	Water level	Base level	Atm. pressure	CH_4		LEL		CO_2		O_2			H_2S		Flow	
		(m)	(m bgl)	(m bgl)	(mbar)	(%)		(%)		(%)		(%)			(ppm)		(l/hr)	
						peak	steady	peak	steady	peak	steady	high	steady	low	peak	steady	peak	steady
BH08	08:45	5.0-6.0	3.08	5.90	1000	0.3	0.0	2.6	0.0	0.0	0.0	20.2	20.2	20.2	0	0	0.0	0.0
BH09	12:55	5.0-6.0	1.86	6.03	999	0.8	0.4	20.0	14.0	19.0	9.6	6.7	6.0	6.0	0	0	-12.0	0.0
BH11*[1&6]	08:35	3.0-4.3	3.28	4.30	1000	18.8	4.0-18.8	+++	+++	0.0	0.0	8.0	2.4-8.0	2.4	0	0	0.0	0.0
BH12	14:15	6.5-7.5	1.55	6.85	998	0.0	0.0	0.0	0.0	0.4	0.4	20.2	20.2	20.2	0	0	0.9	0.0
BH13	12:35	3.0-4.0	*[4]	4.05	1000	0.0	0.0	0.0	0.0	0.5	0.5	18.3	18.3	18.3	0	0	0.0	0.0
BH15	10:35	3.5-4.5	2.40	4.36	1000	0.8	0.0	18.0	0.0	2.2	0.9	19.5	19.5	19.5	0	0	0.0	0.0
BH16*[3]	13:30	1.0-4.0	2.46	2.55	999	0.0	0.0	0.0	0.0	0.3	0.3	20.1	20.1	20.1	0	0	4.0	0.0
BH18	10:05	4.0-5.0	2.40	4.64	1000	0.9	0.9	15.2	15.2	2.9	2.3	15.2	15.2	15.2	0	0	0.0	0.0
BH19	14:05	12.5-13.5	1.27	13.50	999	0.0	0.0	0.0	0.0	0.0	0.0	20.2	20.2	20.2	0	0	48.0*[5]	0.0
BH23*[3]	13:55	5.0-6.0	1.62	5.10	999	0.0	0.0	0.0	0.0	0.2	0.2	20.5	20.5	20.5	0	0	10.5	0.0
BH26	09:50	7.0-8.0	2.10	7.82	1000	0.4	0.4	10.6	10.6	4.6	4.6	15.8	15.8	15.8	0	0	0.0	0.0
BH29	09:26	1.0-5.0	0.80	5.05	1001	0.0	0.0	0.0	0.0	0.8	0.8	20.1	19.9	19.9	0	0	0.0	0.0
BH30*[3]	11:20	9.0-10.0	1.83	7.75	1000	0.0	0.0	0.0	0.0	0.3	0.3	20.4	20.4	20.4	0	0	-15.8	0.0

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Continuous Ground-Gas Monitoring

1st Generation
In-borehole device
GasClam®

2nd Generation
On-borehole device
Gas Sentinel®

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Gas Sentinel®

- **British designed & built by specialists for specialists**
- **Small, light & smart**
- **Telemetry enabled**
- **Continuous flow**
- **Discrete & secure**

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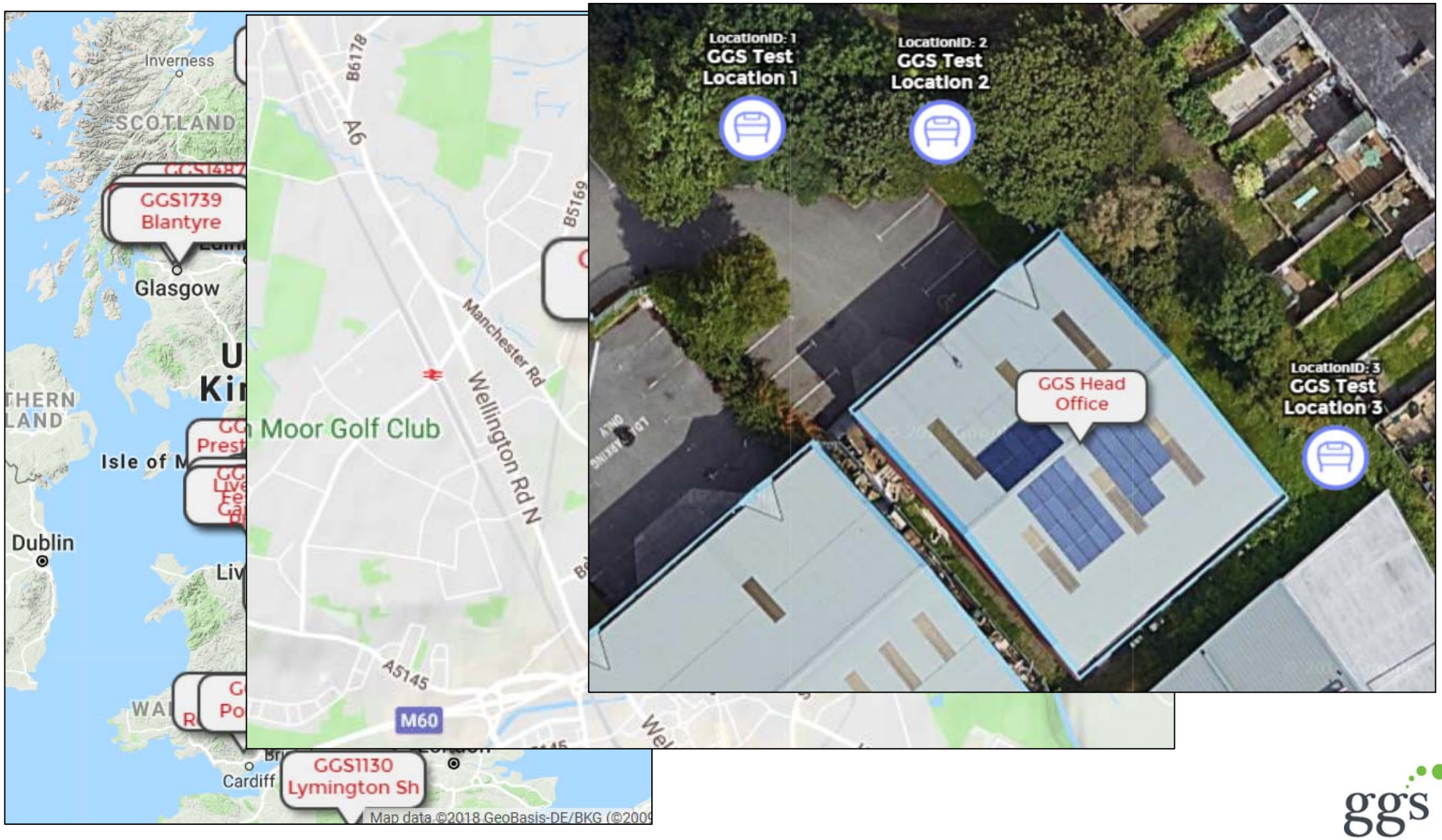
GGS Gas Sentinel®



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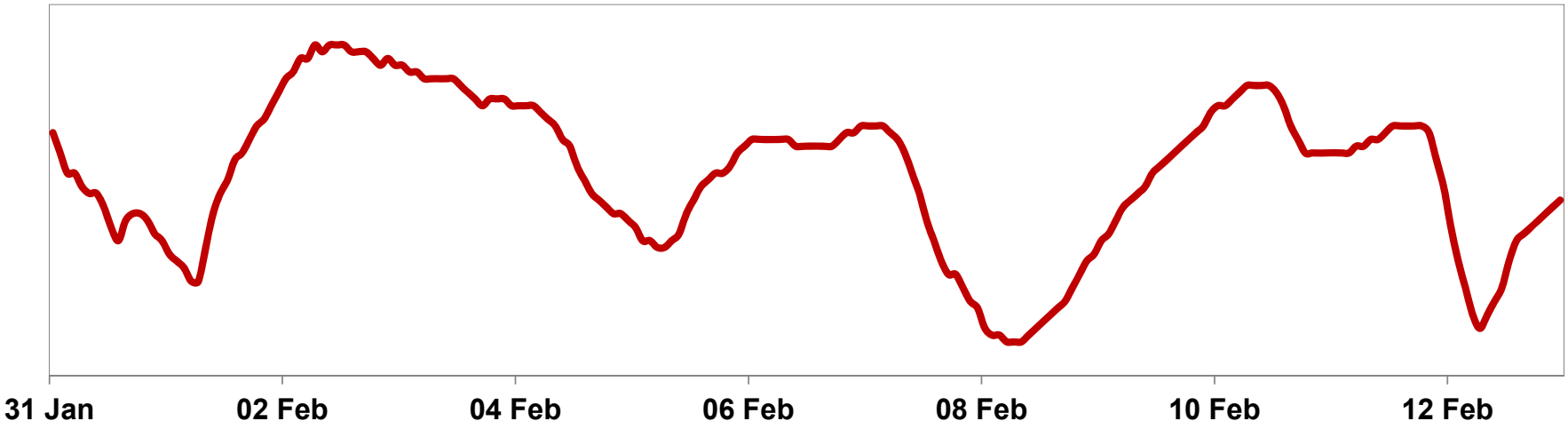
Continuous Monitoring

When the frequency of monitoring **exceeds** the frequency of change of the measured parameter, the monitoring can be termed **'continuous'**



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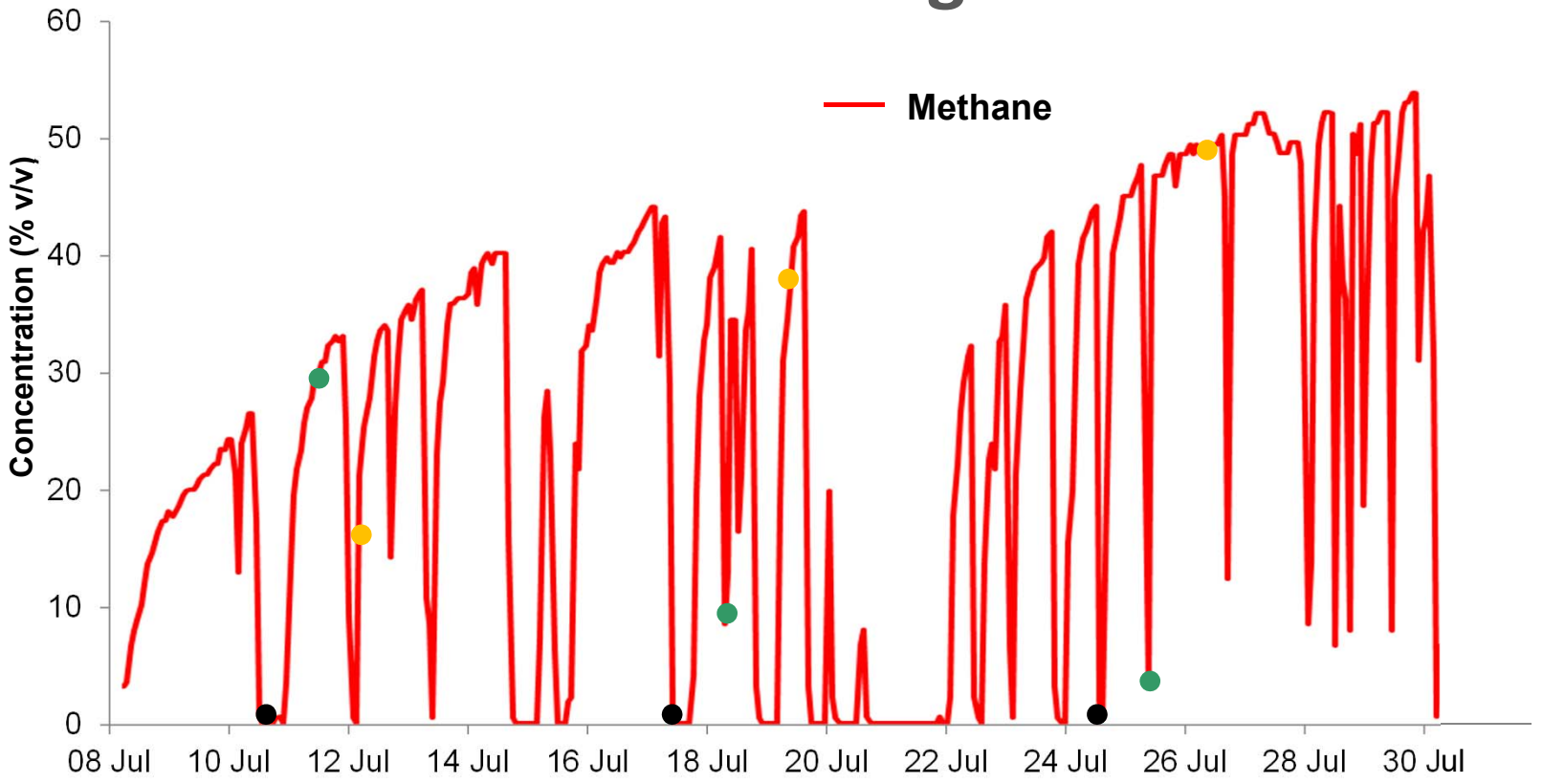
‘Spot’ & ‘Continuous’ monitoring



- Weekly monitoring on these dates shows almost no methane
- Weekly monitoring on these dates shows falling methane
- Weekly monitoring on these dates shows rising methane

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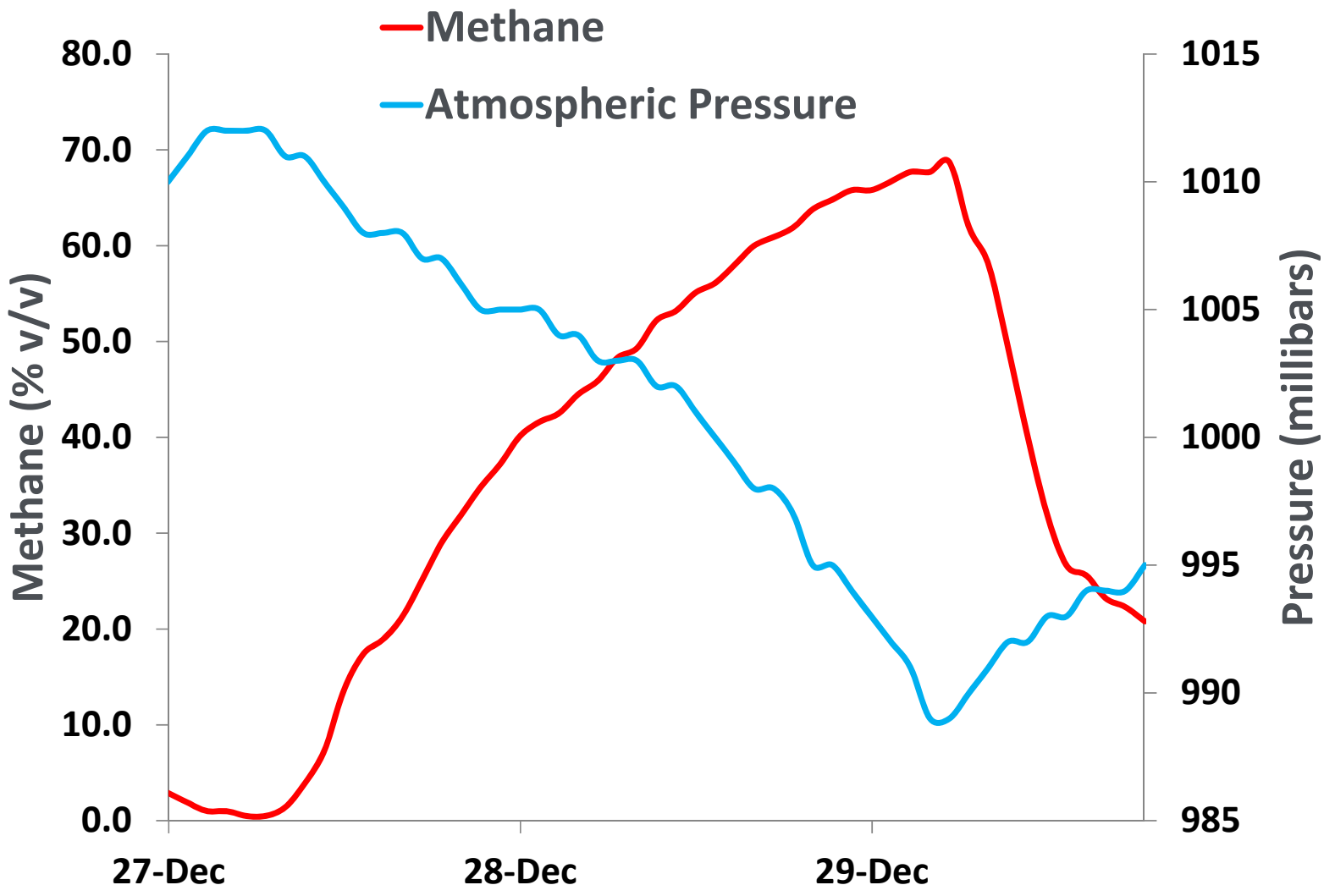
Atmospheric Pressure as a Ground-Gas Driver



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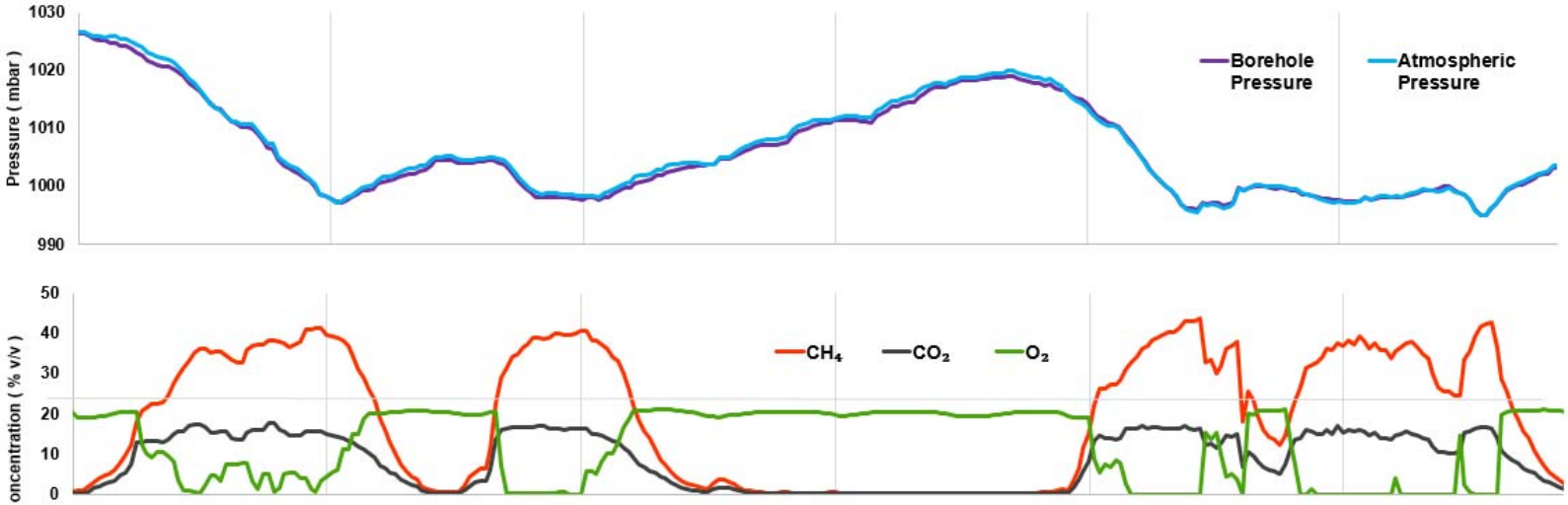
Continuous GSV



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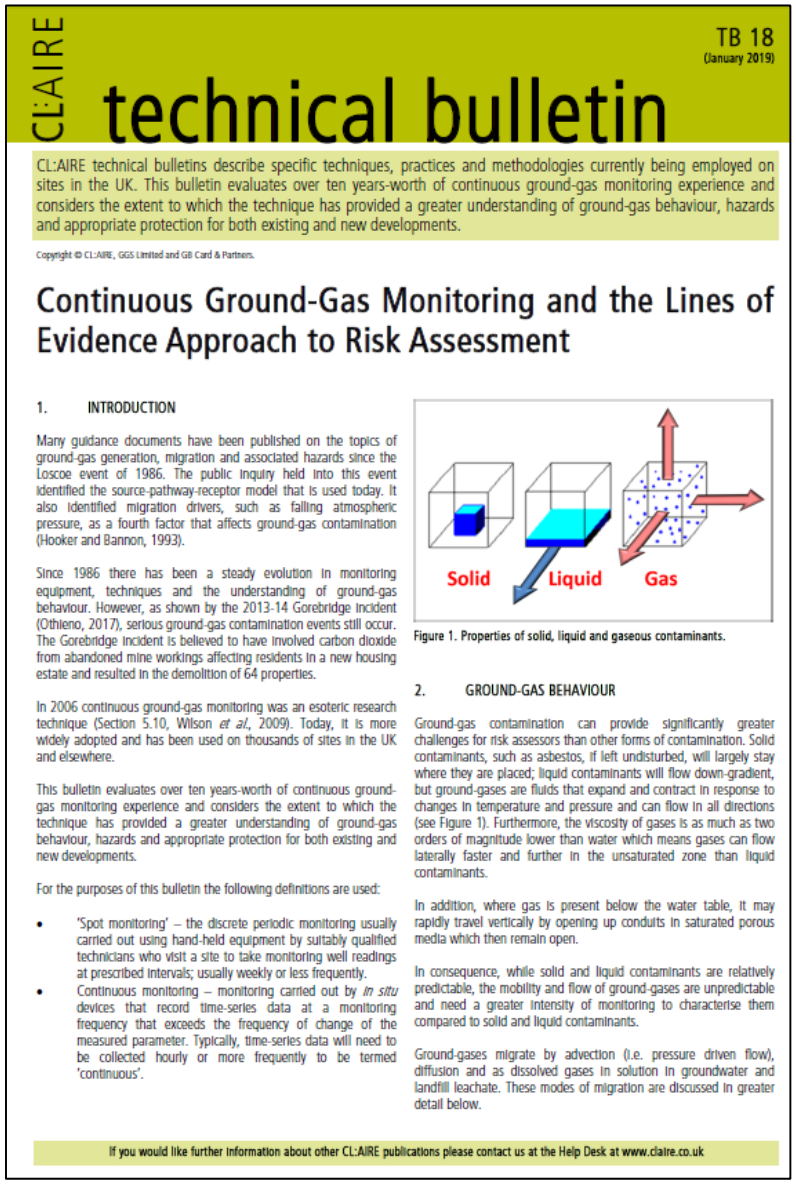

CL:AIRE

TB 18
(January 2019)

technical bulletin

CL:AIRE technical bulletins describe specific techniques, practices and methodologies currently being employed on sites in the UK. This bulletin evaluates over ten years-worth of continuous ground-gas monitoring experience and considers the extent to which the technique has provided a greater understanding of ground-gas behaviour, hazards and appropriate protection for both existing and new developments.

Continuous Ground-Gas Monitoring and the Lines of Evidence Approach to Risk Assessment

1. INTRODUCTION

Many guidance documents have been published on the topics of ground-gas generation, migration and associated hazards since the Loscoe event of 1986. The public inquiry held into this event identified the source-pathway-receptor model that is used today. It also identified migration drivers, such as falling atmospheric pressure, as a fourth factor that affects ground-gas contamination (Hooker and Bannon, 1993).

Since 1986 there has been a steady evolution in monitoring equipment, techniques and the understanding of ground-gas behaviour. However, as shown by the 2013-14 Gorebridge incident (Othieno, 2017), serious ground-gas contamination events still occur. The Gorebridge incident is believed to have involved carbon dioxide from abandoned mine workings affecting residents in a new housing estate and resulted in the demolition of 64 properties.

In 2006 continuous ground-gas monitoring was an esoteric research technique (Section 5.10, Wilson *et al.*, 2009). Today, it is more widely adopted and has been used on thousands of sites in the UK and elsewhere.

This bulletin evaluates over ten years-worth of continuous ground-gas monitoring experience and considers the extent to which the technique has provided a greater understanding of ground-gas behaviour, hazards and appropriate protection for both existing and new developments.

For the purposes of this bulletin the following definitions are used:

- 'Spot monitoring' – the discrete periodic monitoring usually carried out using hand-held equipment by suitably qualified technicians who visit a site to take monitoring well readings at prescribed intervals; usually weekly or less frequently.
- Continuous monitoring – monitoring carried out by *in situ* devices that record time-series data at a monitoring frequency that exceeds the frequency of change of the measured parameter. Typically, time-series data will need to be collected hourly or more frequently to be termed 'continuous'.

Figure 1. Properties of solid, liquid and gaseous contaminants.

2. GROUND-GAS BEHAVIOUR

Ground-gas contamination can provide significantly greater challenges for risk assessors than other forms of contamination. Solid contaminants, such as asbestos, if left undisturbed, will largely stay where they are placed; liquid contaminants will flow down-gradient, but ground-gases are fluids that expand and contract in response to changes in temperature and pressure and can flow in all directions (see Figure 1). Furthermore, the viscosity of gases is as much as two orders of magnitude lower than water which means gases can flow laterally faster and further in the unsaturated zone than liquid contaminants.

In addition, where gas is present below the water table, it may rapidly travel vertically by opening up conduits in saturated porous media which then remain open.

In consequence, while solid and liquid contaminants are relatively predictable, the mobility and flow of ground-gases are unpredictable and need a greater intensity of monitoring to characterise them compared to solid and liquid contaminants.

Ground-gases migrate by advection (i.e. pressure driven flow), diffusion and as dissolved gases in solution in groundwater and landfill leachate. These modes of migration are discussed in greater detail below.

CL:AIRE TB18 - 2019

- Best practice guide built on over 12 years experience of continuous monitoring
- Over 500 projects reviewed
- Develops the 'Lines of Evidence' approach

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Ground-Gas Protection Process

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Ground-Gas Risk Assessments

Tier 1 - Is there a credible pollutant linkage?

- Desk Study, site recognisance
- Preliminary Conceptual Site Model (CSM)

Tier 2 - Generic Risk Assessment

- What is the empirical level of risk? Need sufficient monitoring data to determine a GSV and a Characteristic Situation (CS)

Tier 3 - Site specific risk assessment

- Qualitative and quantitative assessment
- Use of numeric models (based on sound evidence)

Tier 4 - Receptor monitoring

- Collection of receptor specific data
- Compare directly against safety criteria

Which ever tier – use multiple lines of evidence

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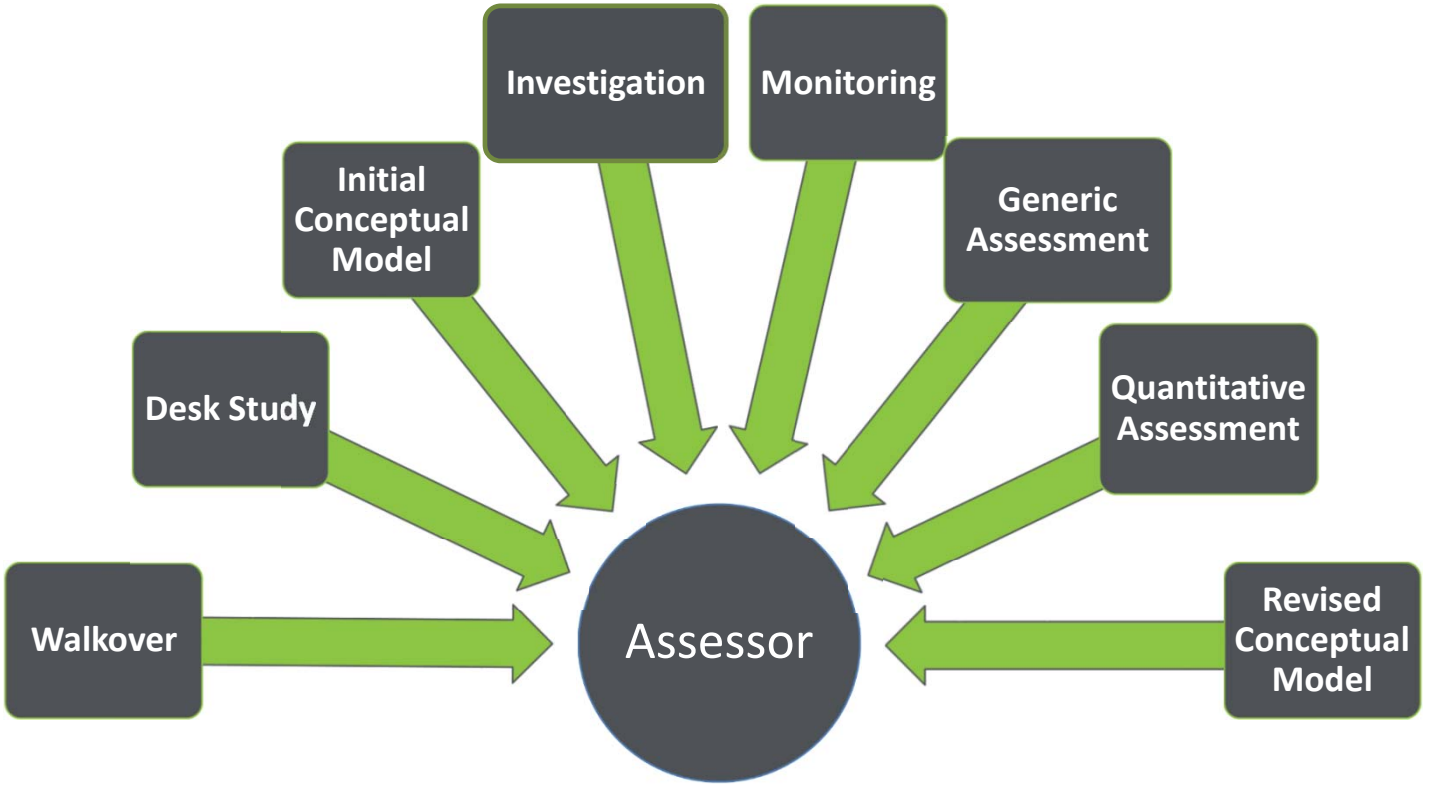
Multiple Lines of Evidence



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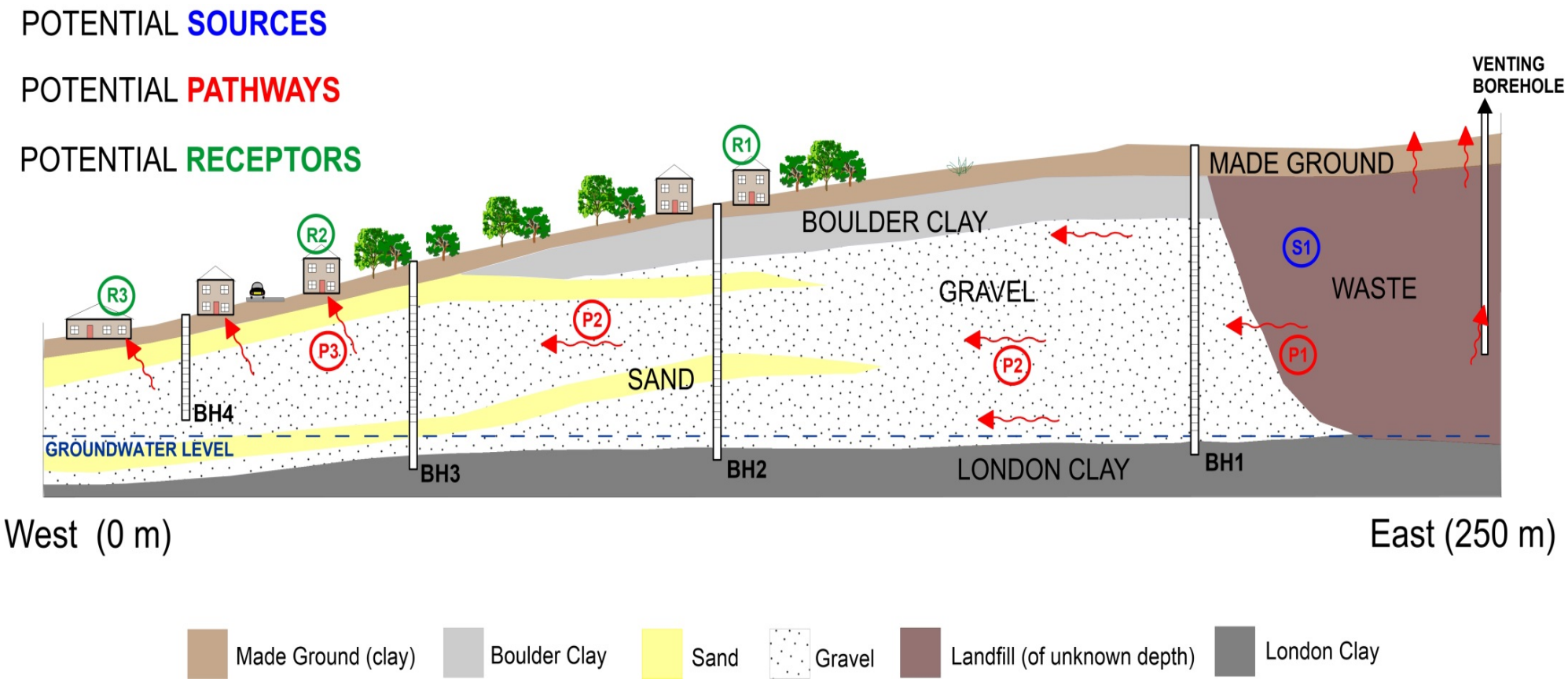
PCSM Cross-section



BS8576 requires cross-sections for migration of permanent gases

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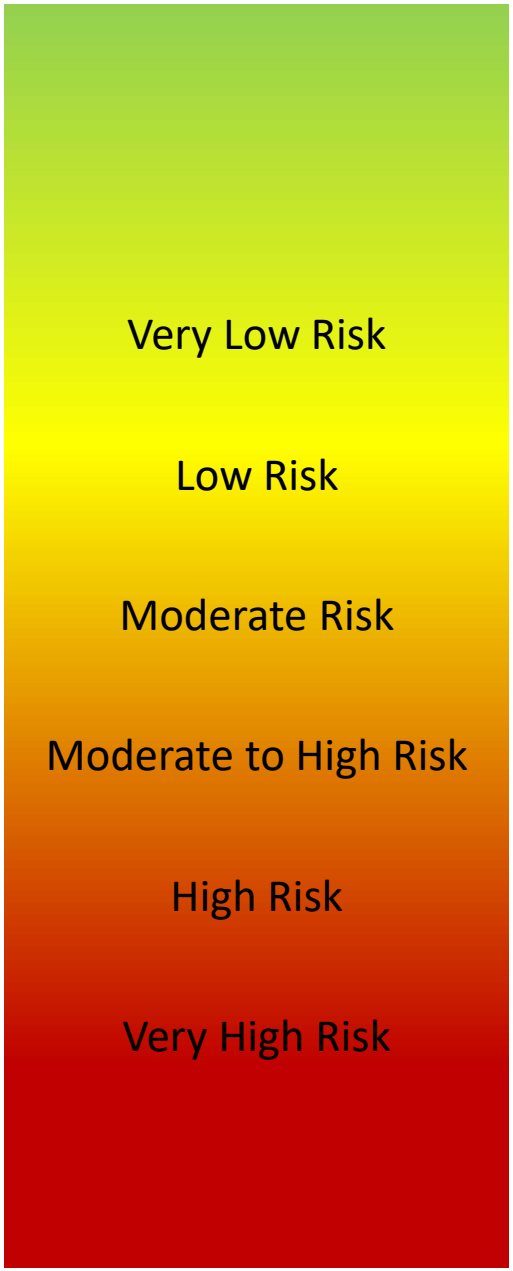
BS8485:2015+A1:2019
Characteristic Situations



CS1	Very Low Risk	No special precautions required.
CS2	Low Risk	Passive Gas Protection (<30m span).
CS3	Moderate Risk	Highest level of passive protection and limit for private unmanaged residential dwellings.
CS4	Moderate to High Risk	Lower active systems for commercial and industrial. Managed residential possible with care.
CS5	High Risk	Large industrial sheds with large open areas. Really think about it.
CS6	Very High Risk	Yes even here you can, but should you be building on it?

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Ground-Gas Protection Process

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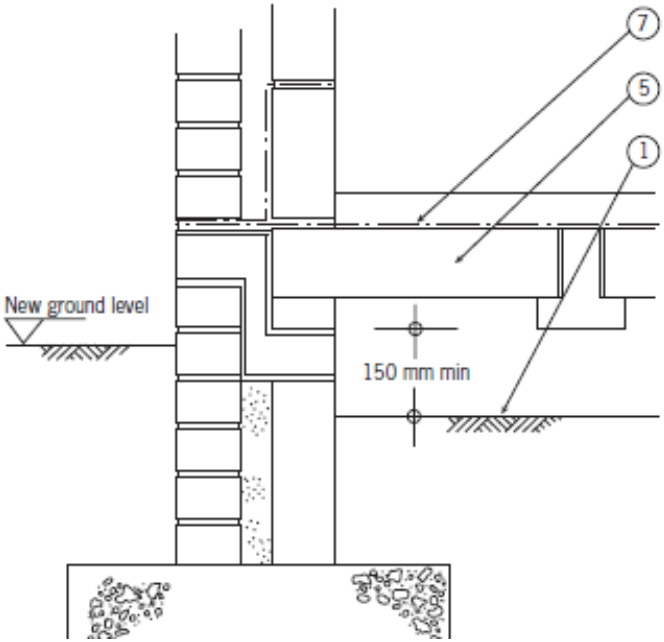
Protecting the Building Envelope

A) Dilute and disperse (provide a preferential pathway to atmosphere)

B) Exclude ground-gases



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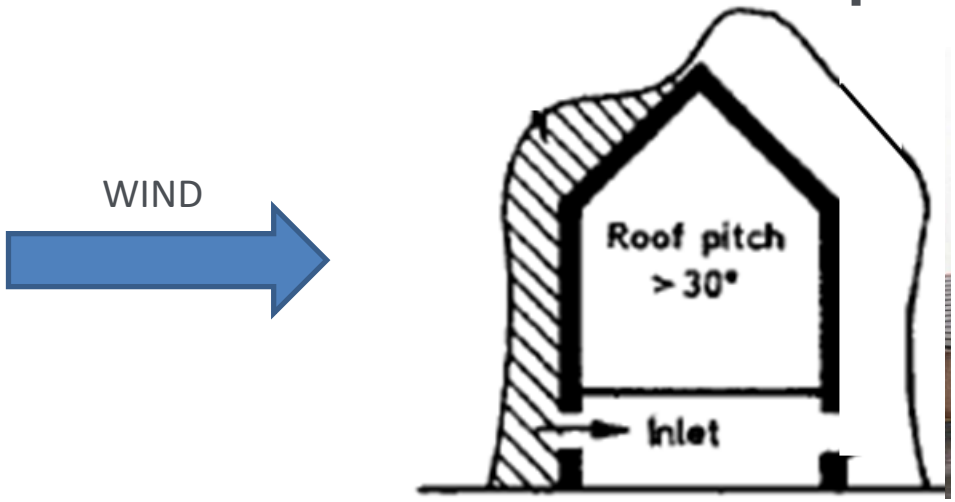
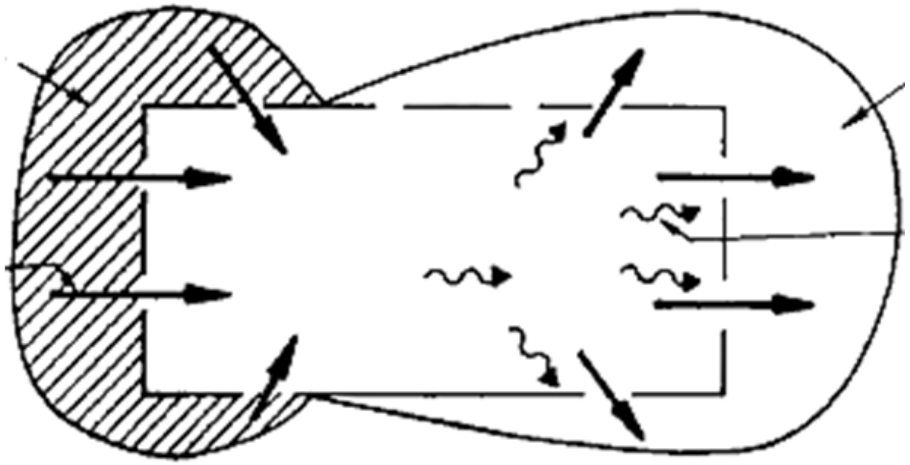
Principle of Passive Dilute and Disperse in Ventilated Void



Plan

Zone of positive pressure



Zone of negative pressure (suction)

CIRIA 149, 1995

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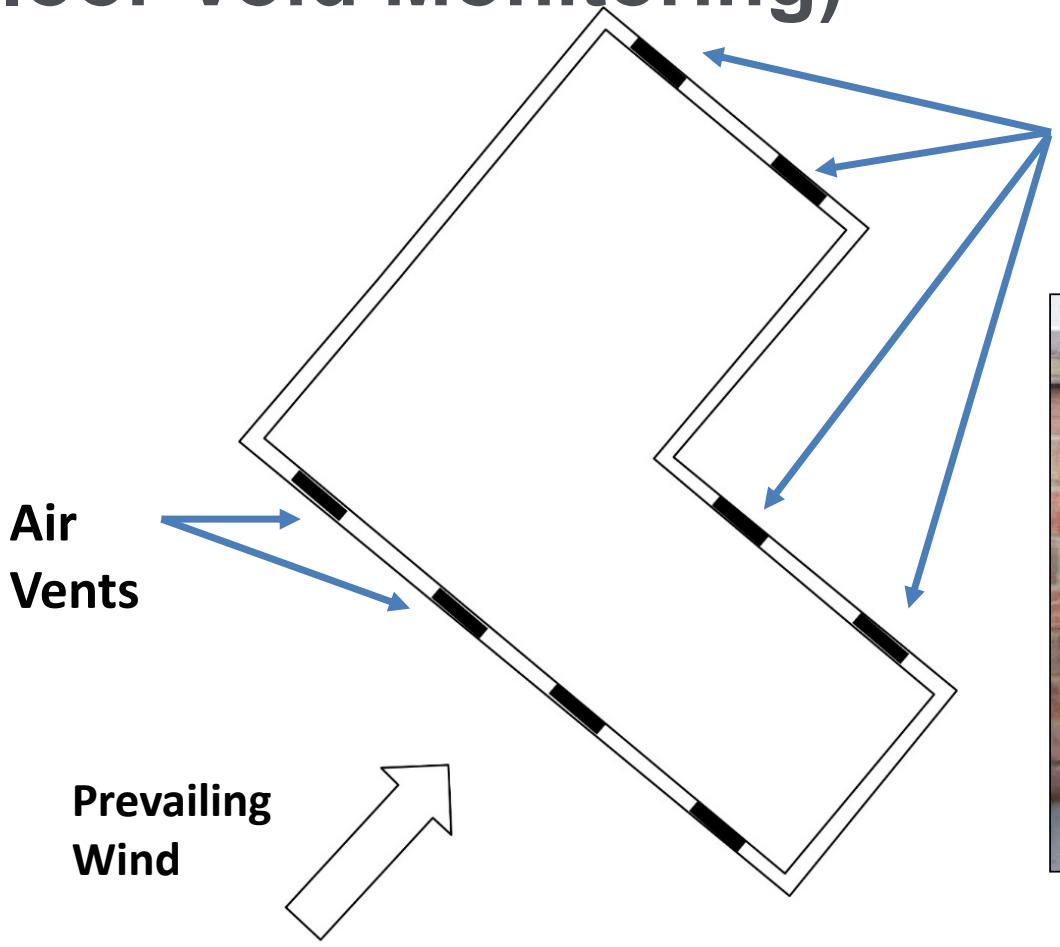
Receptor Monitoring
(Sub-floor Void Monitoring)



Continuous monitoring on the down-wind side

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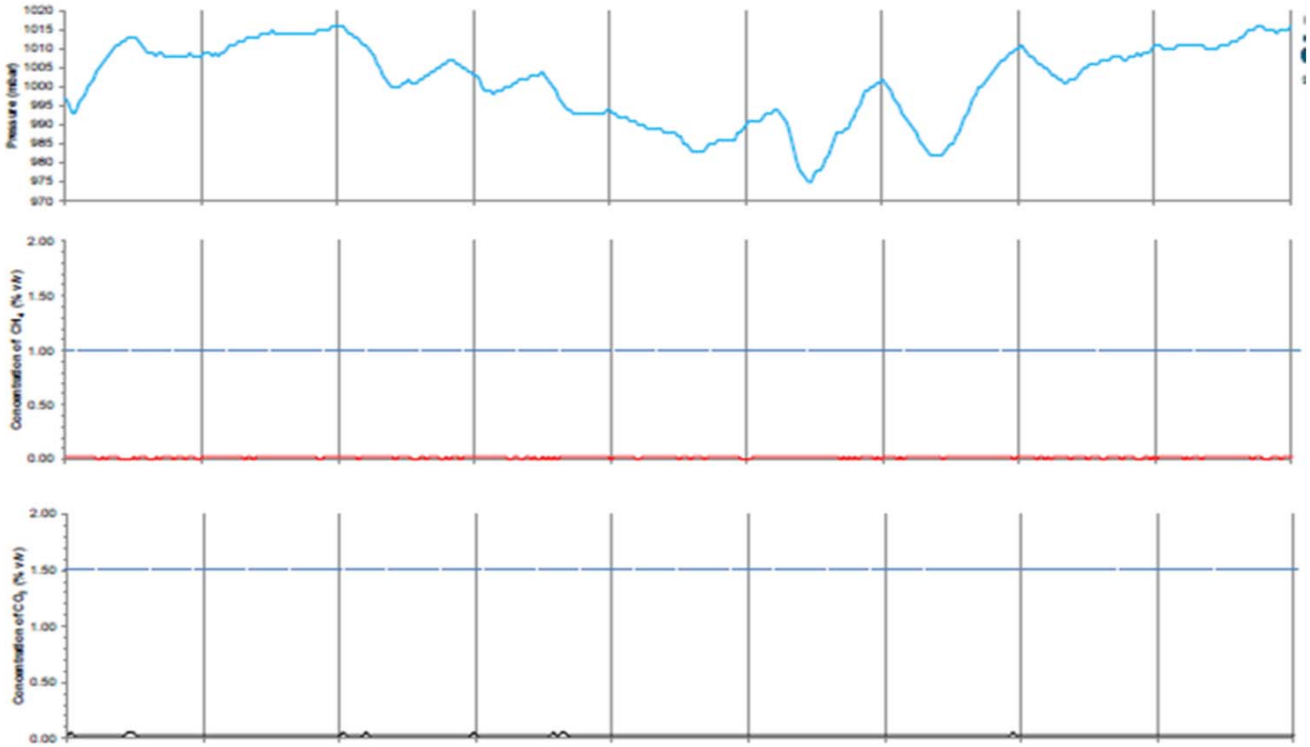
Verification by Measurement (Sub-floor Monitoring)



High sensitivity and resolution sensors

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Excluding Ground-Gases

Unqualified

- A very poorly skilled ground-worker

Qualified

- National Occupational Standards VR 612 and VR 613
- NVQ level 2 qualification in gas membrane installation

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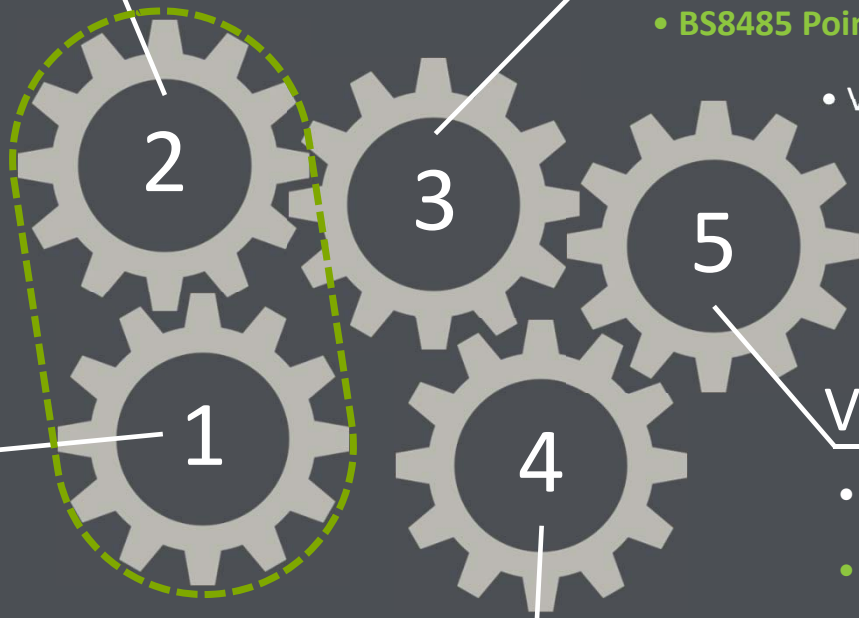
Verification Testing

- INDEPENDENT
- Visual Inspection and Pick Testing through to Integrity Testing and Gas Monitoring
- It should be used proportionally and appropriately
- There are a number of different methods currently available
- Further information is included in CIRIA C735 guidance
- NVQ Level 4 Qualification

Ground-Gas Protection Process



1 Risk Assessment

- **Desk Study**
- Conceptual Site Model
- **Consideration of gases and vapours**
- Generic GSV
- **Detailed assessment**
- Assigning Characteristic Situation

2 Site Investigation

- Boreholes
- **Monitoring**
- BS8576
- Laboratory analysis

Weeks to Months

3 Design & Specification

- Proportionate to the risks posed
- **BS8485 Points Scoring System**
- Ventilation
- Structure
- Membrane

BS8102 Considerations

4 Installation

- NVQ Level 2 Installation Qualification
- **Protection from Follow on Trades**

5 Verification

- NVQ Level 4 Qualification
- **CIRIA C735**
- Verification Plan
- **Integrity Testing**
- Independent

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ground - gas solutions limited

The A-Z of Ground-Gas

Two days of theory and practical

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PAGeoTechnical

5 & 6 Feb	Liverpool
26 & 27 Mar	Milton Keynes
30 Apr & 1 May	Warwick
11 & 12 Jun	Edinburgh
9 & 10 Jul	Central London
24 & 25 Sept	Portsmouth
5 & 6 Nov	Cardiff
26 & 27 Nov	Leeds

http://www.ggs-uk.com/ground-gas-services/ggs-training/

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2019 GGS training webinars

1. The development and principles of continuous ground-gas monitoring	11:00 am 13 March
2. Best practice in collecting continuous data	11:00 am 19 June
3. Continuous monitoring and the source-pathway-receptor (pollutant linkage) model	11:00 am 11 September
4. Continuous receptor monitoring (including sub-floor void monitoring)	11:00 am 20 November

http://www.ggs-uk.com/ground-gas-services/ggs-training/

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Thank you !

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