

Housekeeping...



Please stay on mute



Turn camera off if you don't want to appear in the recording

Ask a question in the chat



Want to ask a question during Q&A?

Type 'Hand up' in the chat





Experts in Continuous Monitoring

**TB18 - Using multiple 'lines of evidence' to
move gas risk assessment beyond GSV**

Matt Askin

Scottish Contaminated Land Forum

20th May 2021



Please do ask questions

Type your questions as they occur in the Q&A box (bottom of screen menu)

I'll go through these at the end.





Loscoe 1986

Importance of the Source-Pathway-Receptor Model
and
Key driver mechanisms



Loscoe 1986

Importance of the Source-Pathway-Receptor Model
and
Key driver mechanisms



Cranbourne, Melbourne 2010

Landfill gas is a serious hazard and the site specific
geology affects its migration, over long distances



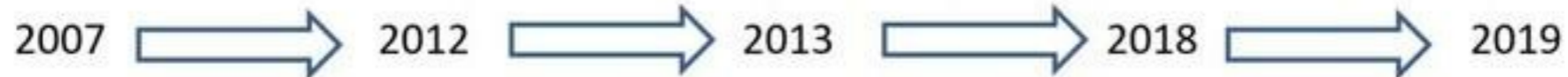
Gorebridge 2013

Changing the ground-conditions will change the
ground-gas risk

Development of guidance & standards



Development of guidance & standards



Development of guidance & standards

<p>CIRIA S Wilson S Oliver H Milled H Milled G Card</p> <p>Ass haz to b</p>	<p>CLAIRE</p> <p>re</p> <p>CLAIRE research bulletin monitoring or remediation risk assessment</p> <p>Example TB 18, 2019</p> <p>A Pragmatic</p> <p>ABSTRACT</p> <p>Measurement of ground gas to assess contamination of the deep ground is not yet a common practice and the interpretation of results is often confusing with a wide range of monitoring techniques being used.</p> <p>A more robust assessment of the ground gas monitoring data is needed to allow the data to be used to identify areas of contamination. This paper discusses the various methods used to monitor ground gas and provides a framework for the interpretation of the data. The paper also discusses the importance of the data in assessing the risk of contamination and the importance of the data in assessing the risk of contamination.</p> <p>The approach for the data analysis is discussed and the importance of the data in assessing the risk of contamination is discussed.</p> <p>1. INTRODUCTION</p> <p>Recent ground gas monitoring data has shown that the data is often of a low quality and is often inconsistent with the data from other monitoring techniques.</p> <p>1. An assessment of the data is needed to allow the data to be used to identify areas of contamination.</p> <p>2. A framework for the interpretation of the data is needed to allow the data to be used to identify areas of contamination.</p> <p>3. A standard for the interpretation of the data is needed to allow the data to be used to identify areas of contamination.</p> <p>For further information, please contact the authors at www.ciria.gov.uk</p>	<p>BSI Standards Publication</p> <p>Guidance on for ground gas gases and Vol Compounds (</p> <p>raising standards worldwide™</p>	<p>CLAIRE technical bulletin</p> <p>Ground Gas Monitoring and 'Worst-Case'</p> <p>1. INTRODUCTION</p> <p>The technical bulletin provides guidance on the critical parameters to consider when monitoring ground gas and provides a clear framework to allow the data to be used to identify areas of contamination.</p> <p>Current guidance on ground gas monitoring suggests that it should be carried out over a sufficient period to allow the data to be used to identify areas of contamination. However, this is often not possible due to the high cost of monitoring and the limited availability of monitoring equipment.</p> <p>For example, in Western Australia the cost of monitoring is often in the order of \$1000 per site per month. This is a significant cost and is often not justified by the limited data that can be obtained.</p> <p>The BSI Ground Gas Monitoring Guidance is based on the following principles:</p> <ul style="list-style-type: none"> • Gradual fall – 400-500 ppm • Sharp fall – 400-500 ppm • Very sharp fall – 400-500 ppm <p>Some exceptions to this are: • In areas where the ground gas is known to be of a high concentration, a shorter monitoring period may be justified.</p> <p>ES&R recommends that the data should be used to identify areas of contamination and that the data should be used to assess the risk of contamination.</p> <p>2. BAROMETRIC PRESSURE VARIATIONS</p> <p>Controls of the weather pattern in the UK, to specify that ground gas monitoring should be carried out over a period of at least 12 months. This has been reduced to a minimum of 6 months in the latest guidance document. This has been reduced to a minimum of 6 months in the latest guidance document. This has been reduced to a minimum of 6 months in the latest guidance document. This has been reduced to a minimum of 6 months in the latest guidance document.</p> <p>If you would like further information about other CLAIRE publications please contact us at the Help Desk at www.ciria.gov.uk</p>	<p>CLAIRE technical bulletin</p> <p>Continuous Ground-Gas Monitoring and the Lines of Evidence Approach to Risk Assessment</p> <p>1. INTRODUCTION</p> <p>Many previous documents have been published on the topic of ground-gas monitoring, but the understanding of ground-gas behaviour has improved since the 2012 TB (Technical Bulletin 18, 2012) on ground-gas monitoring. This TB also discusses the importance of the data in assessing the risk of contamination and the importance of the data in assessing the risk of contamination.</p> <p>Since 2012 there has been a steady increase in monitoring equipment, techniques and the understanding of ground-gas behaviour. However, as shown by the 2012 TB (Technical Bulletin 18, 2012), the ground-gas monitoring data is often of a low quality and is often inconsistent with the data from other monitoring techniques.</p> <p>The BSI Ground Gas Monitoring Guidance is based on the following principles:</p> <ul style="list-style-type: none"> • Gradual fall – 400-500 ppm • Sharp fall – 400-500 ppm • Very sharp fall – 400-500 ppm <p>Some exceptions to this are: • In areas where the ground gas is known to be of a high concentration, a shorter monitoring period may be justified.</p> <p>ES&R recommends that the data should be used to identify areas of contamination and that the data should be used to assess the risk of contamination.</p> <p>2. GROUND-GAS BEHAVIOUR</p> <p>Ground-gas contamination can occur in a number of ways including: • Diffusion from areas of contamination • Seepage from areas of contamination • Seepage from areas of contamination • Seepage from areas of contamination</p> <p>The data should be used to identify areas of contamination and that the data should be used to assess the risk of contamination.</p> <p>If you would like further information about other CLAIRE publications please contact us at the Help Desk at www.ciria.gov.uk</p>
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Gas Screening Value (GSV)

GSV – What is it?

A single, calculated value based on periodic monitoring results, implying a characteristic risk situation.

How is it calculated?

Max observed concentration (CH₄% & CO₂%) x Worst case borehole flow (L/hr)

So, simple right?

In (“professional”) practice, probably too simple.

What’s the problem?

Ground gas behaviour is seldom stable or predictable

Concentration (out of context) is not necessarily a driver of risk

Measured flow can be influenced many things....some material, some irrelevant.

Very often overlooked but....GSV was intended as a *Guideline value, not an absolute threshold.*

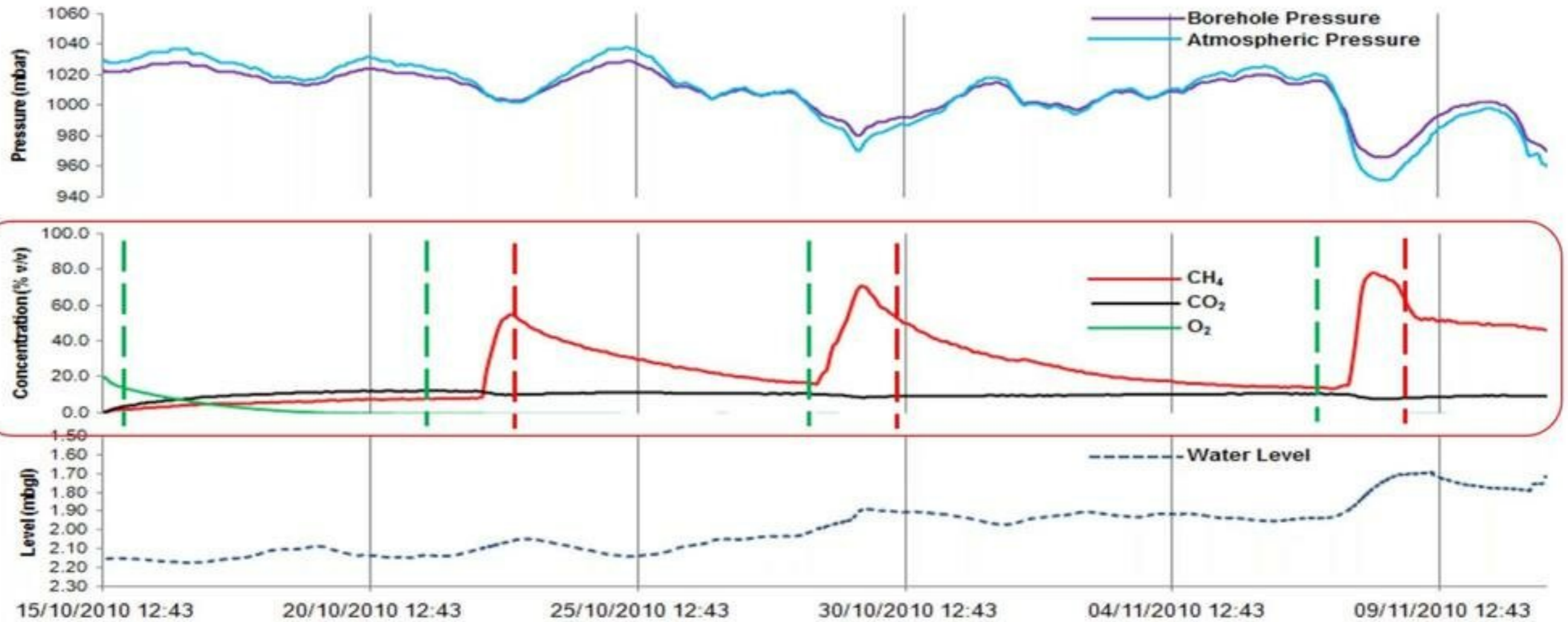
So, beyond GSV? Yes, but not how you might expect.

GSV is a recognised and accepted metric, but it’s real value is as part of a detailed CSM and when **informed by** and **consistent with** all lines of evidence.

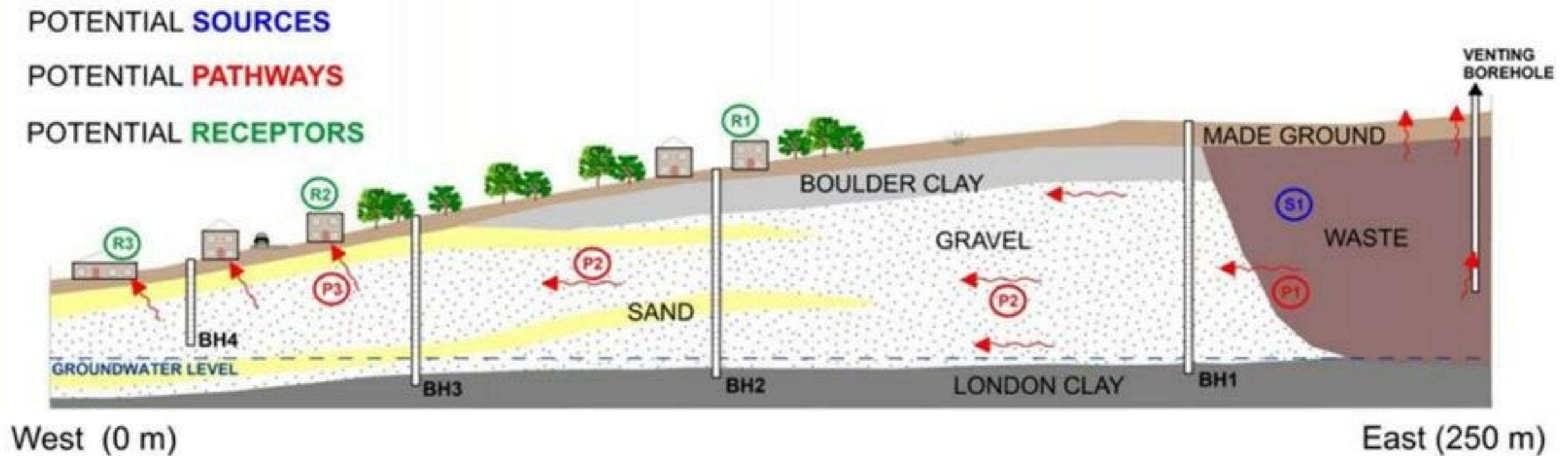


Ground gas behaviour & variability

Ground gas behaviour & variability



Importance of the Conceptual Site Model (CSM)



Made Ground (clay)
 Boulder Clay
 Sand
 Gravel
 Landfill (of unknown depth)
 London Clay

Risk Assessment Tier 1 – Is there a potential pollutant linkage?

Tier 2 - Generic risk assessment (inc. GSV)

Tier 3 – Detailed risk assessment (inc. LoE)

Multiple
Lines of
Evidence


 Experts in Continuous Monitoring

Desk Study Data Sets



British Geological Survey

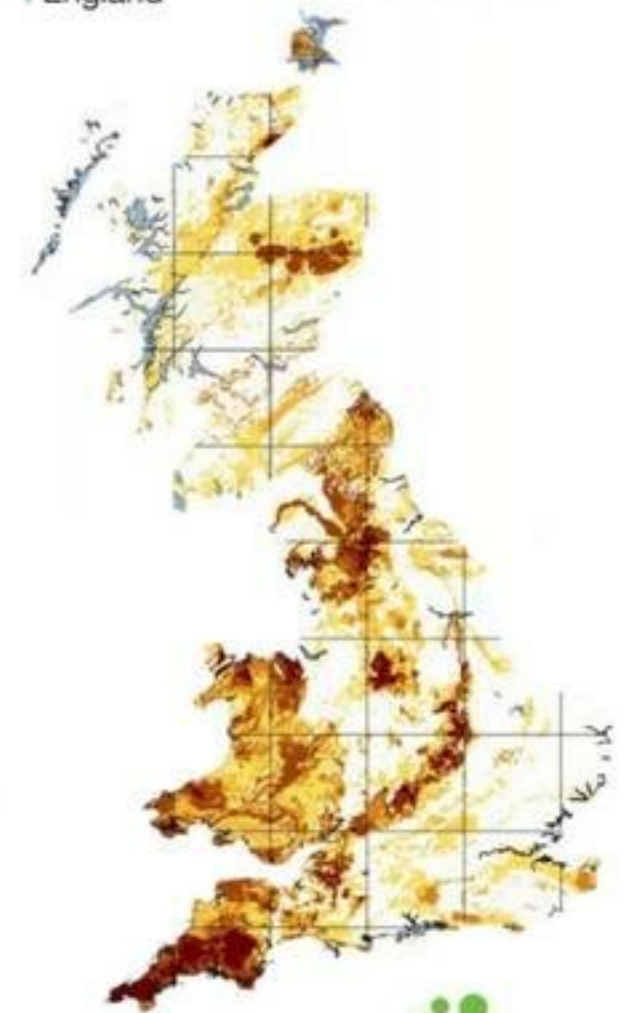


The Coal Authority



Public Health England

bre



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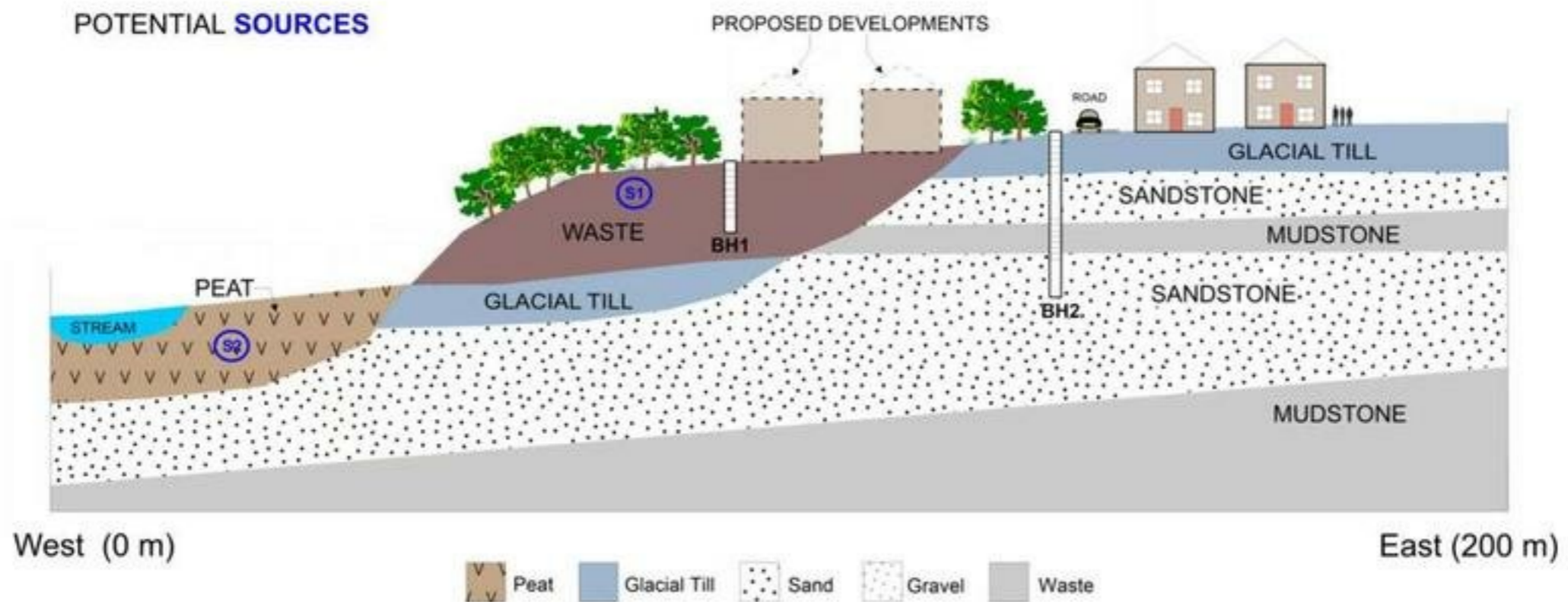
Historical Maps



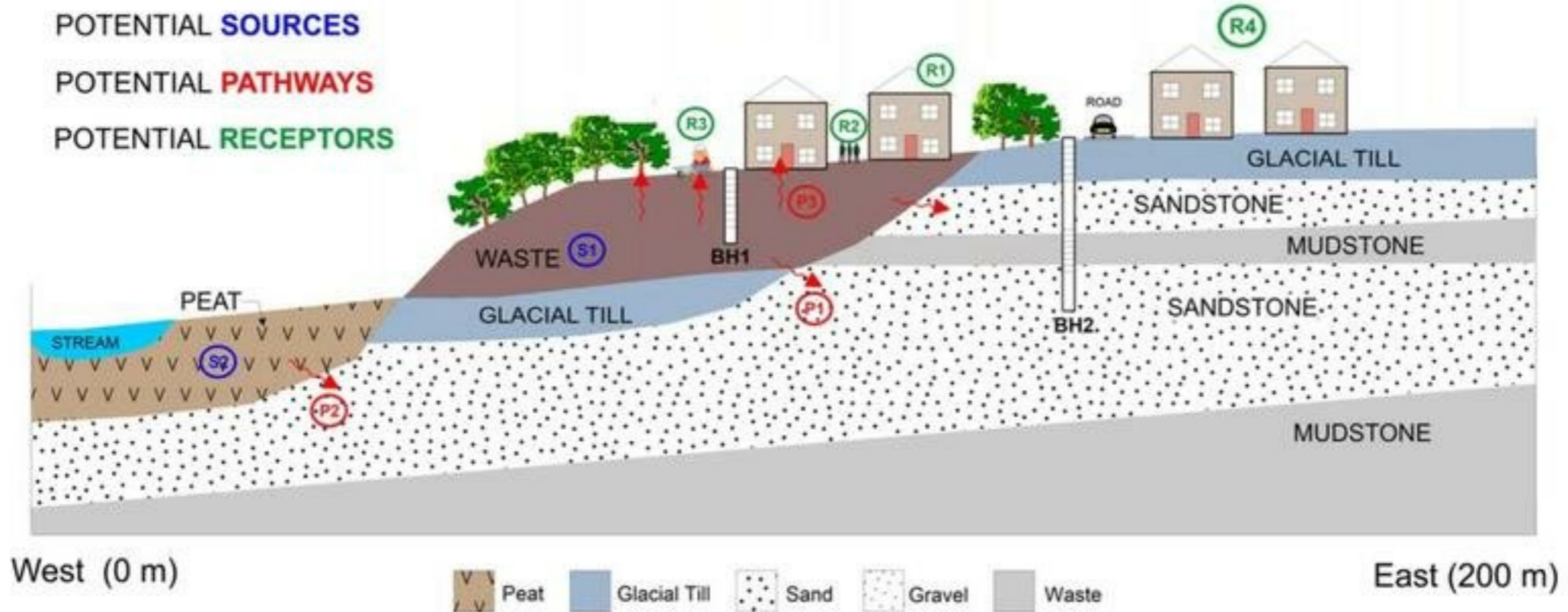
<http://www.archiuk.com/>



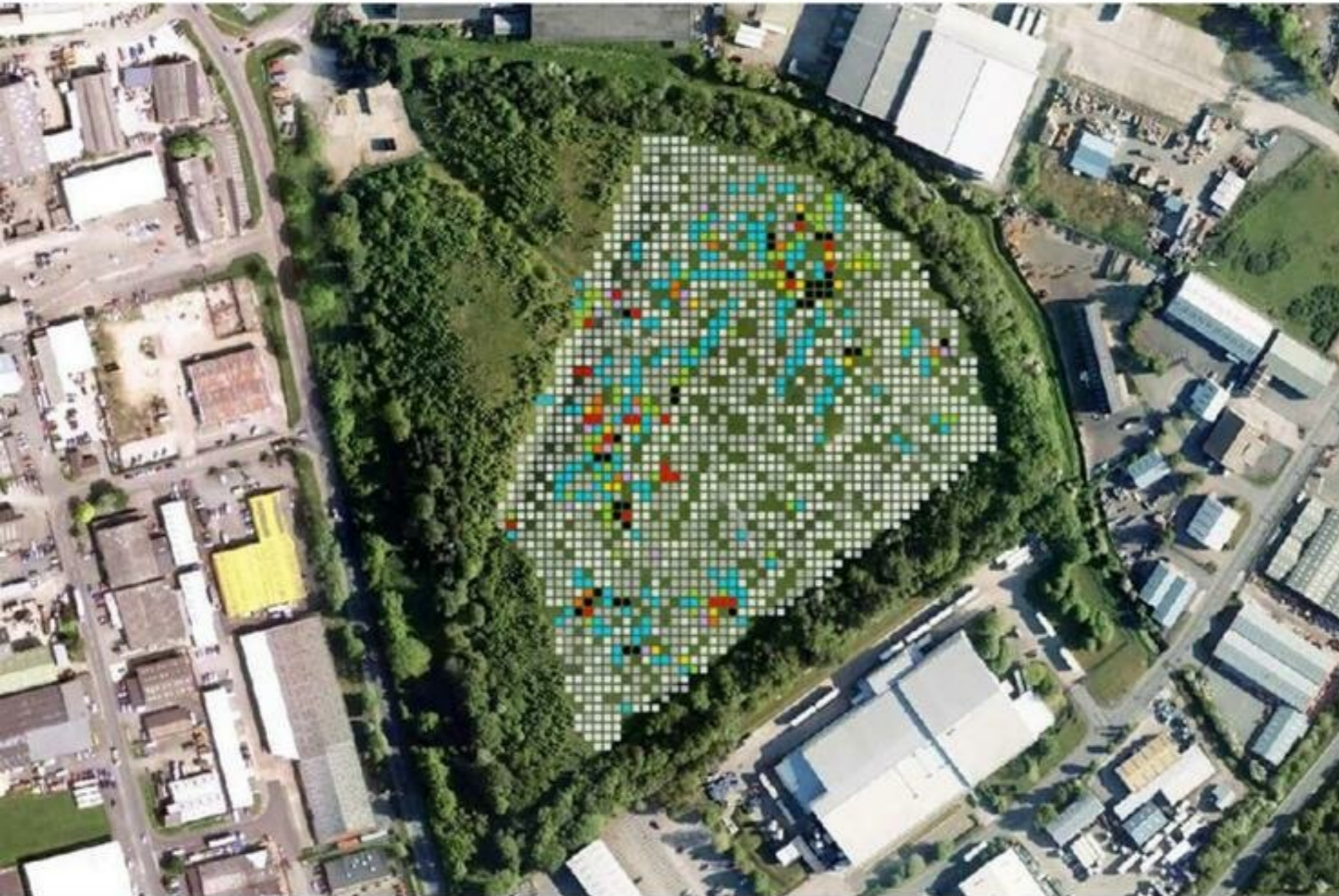
Preliminary Conceptual Site Model



Preliminary Conceptual Site Model



Surface Emission Surveys



Legend

Methane concentration (ppmv)

- < 2.5
- 2.5 - 4.9
- 5.0 - 9.9
- 10.0 - 24.9
- 25.0 - 49.9
- 50.0 - 99.9
- 100.0 - 999.9
- 1000.0 - 9999.9

Trial Pitting



Excavation Method		Dimensions		Ground Level (mOD)		Client		Job Number	
Trial Pit		1.5x5.0x0.7m		175.16		Ground Gas Solutions			
		Location		Dates		Project Contractor		Sheet	
				21/09/2018				1/1	
Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description		Legend	Water
				174.86	(0.30)	MADE GROUND: Grass over dark brown slightly gravelly sandy CLAY with occasional rootlets (topsoil). Sand is fine to medium. Gravel is fine to medium and subrounded comprising sandstone and mudstone.		[Pattern]	
				174.71	(0.15)				
				174.46	(0.25)	MADE GROUND: Yellowish brown sandy GRAVEL (MOT layer). Sand is fine to medium. Gravel is fine to medium and subangular to subrounded comprising sandstone.		[Pattern]	
					0.70	MADE GROUND: Blackish brown gravelly sandy CLAY with frequent ash, clinker, glass bottles, glass fragments, occasional pottery fragments, brick fragments, plastic and rare newspaper and bone. Sand is fine to medium. Gravel is fine to coarse and subangular to subrounded comprising sandstone and mudstone. Wet grey clayey SAND layer at base of trial trench. Complete at 0.70m			



Empirical approach using TOC

A Pragmatic Approach to Ground Gas Risk Assessment”

CL:AIRE research bulletin RB 17, 2012

- Only to be used for very low to moderate onsite gas hazard
- Requires carefully planned and executed investigation
- Uses TOC analysis and forensic logging



CL:AIRE

RB 17

November 2012
110 3406 0957

research bulletin

CL:AIRE research bulletins describe specific, practical aspects of research which have direct application to the characterisation, monitoring or remediation of contaminated soil or groundwater. This bulletin describes an alternative approach to ground gas risk assessment.

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A Pragmatic Approach to Ground Gas Risk Assessment

ABSTRACT

Measurement of ground gas in monitoring wells does not always give a suitable indication of the likely hazard to man from its development. This is because the gas concentration, pressure and flow rate measured in a well headspace may not be representative of conditions in the surrounding formation. The number of gas monitoring wells, on a site is also usually limited when compared to the total number of exploratory bore holes (gas, hydrocarbons, etc).

A more robust assessment of the risk posed by the presence of ground gas is required to landfill gas or other gas may be achieved by considering information and data that allow the likely gas generation to be estimated. The proposed scope of gas protection is for immediate remediation in the risk assessment. Simple gas protection measures comprising an under floor venting system and gas resistant membrane have proven to be effective over a wide range of gas sources.

This research bulletin presents a pragmatic approach to ground gas assessment using data that can be collected quickly and at low cost. The data is not subject to any significant external influences, unlike gas monitoring data. The approach can be used to identify where gas monitoring is required to help assess the risk posed to developments by landfill, mine or ground gas. On many sites, especially where gas protection will be provided, it will allow gas well installation and monitoring to be avoided, i.e. where risks of low organic content are present with low ground gas generation potential. It can also be used in conjunction with gas monitoring to reduce the period of monitoring required or to avoid some gas monitoring where preliminary results are recorded.

The approach has been utilised on a wide variety of sites and has been shown to provide an acceptable indication of the scope of gas protection that is required.

1. INTRODUCTION

Several ground gases such as methane and carbon dioxide are found widely in soils and rocks, as they are an integral component of the geochemical cycle of the Earth. Methane and carbon dioxide can also occur due to the activities of man such as landfill waste (landfill gas) and by mining (mine gas). The gases generally pose a risk to developments over or near them when the following occur:

1. An accumulation of large volumes of gas in the ground in or near buildings (internal).
2. A pathway that allows gas to seep through under or over of the ground into a building or other structure sufficiently quickly to allow it to build up inside the building (external).
3. A confined space within the building or structure where gas can build up to unacceptable levels (enclosed).

In other words there needs to be a source – pathway – receptor linkage for the gas hazard to pose a risk to any development. This requires a sufficient quantity of gas to pose a hazard, and one or more pathways by which it may cause significant harm to people. Gas concentration in the ground for monitoring wells should not be confused with volume of gas present. The two are very different and a small volume of gas can give rise to a high concentration in a monitoring well.

Landfill gas generally large volumes of landfill gas and there are many instances where gas has migrated along a pathway and caused explosions or asphyxiation at a receptor (CDA, 2006). More recently the incident in the excavation of a housing estate in Northgate (Brewers, 2008). Similarly mine gas originates from other workings can be large and have caused deaths. As far as the surface, the main risks are to residential receptors where ground gas from Made Good or related soils with a low organic content have caused gas emissions into above ground buildings.

Landfill waste with a high content of degradable organic material can be problematic where landfill gas forms in the pore spaces. The natural process of a gas bubble is normally proportional to its radius so that it can contract in a stable condition in a discrete pore space at relatively high pressures so to a critical value above the critical radius of the soil relative surrounding the pore space will occur and a gas expansion network will form (CDA, 2006). Initial high pressures in sources such as landfills lead to coalescence of pores into a network that can cause large volume release of gas posing the potential risk to building development. Commonly in Made Good and related soils where ground gas generation is very low or has occurred in the geological past the ground gas pressure is much lower. The gas is now effectively trapped in the pore spaces of the soil or it is migrating out of the ground very slowly, for example extensive plume of gas.

Buildings may often already require construction details that provide protection against ground gas ingress. If extra protection is required the soil also gas good resistance to ground gas ingress. Similarly the requirements for air tight construction tend to well sealed floor slabs. For this reason gas monitoring in low risk sites where small volumes of gas are likely to be present in the soil pores, or where other protection or air tightness is already required is not always necessary.

This bulletin presents an alternative framework for the investigation and assessment of ground gas that takes into account the preceding considerations. It should allow gas well installation and monitoring to be avoided where appropriate. It can also be used in conjunction with gas monitoring to reduce the period of monitoring required or to avoid some gas monitoring where monitoring results, particularly high headspace flow rates, are recorded.

The approach is based on principles described in the "Local authority guide to ground gas" published by the Chartered Institution of Environmental Health (CIEH).

For further information, please contact the authors: Geoff Cook at gcook@claire.aire.com, Steve Wilson at steve@claire.aire.com and Sarah Morrison at sarah@claire.aire.com

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Empirical approach using TOC

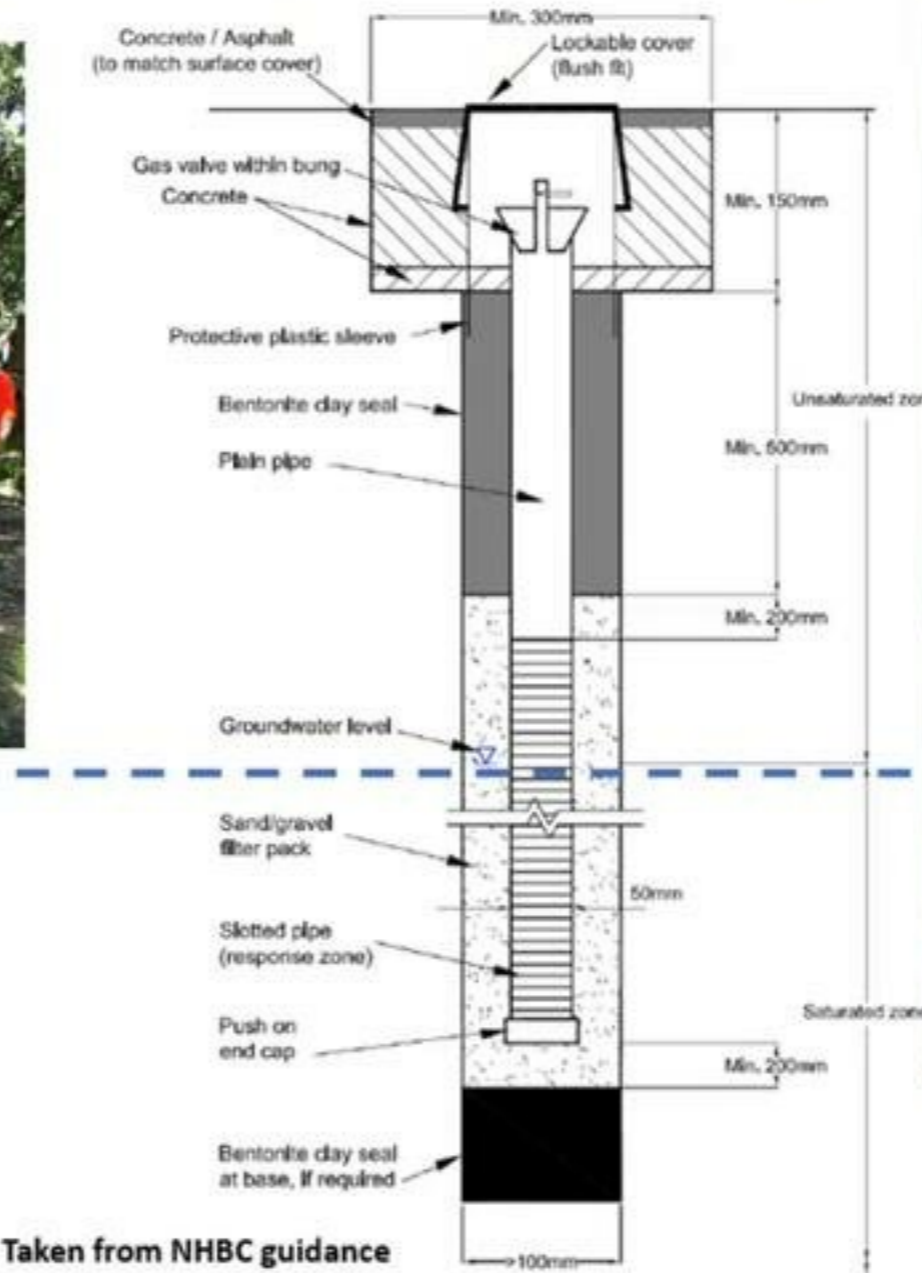
A Pragmatic Approach to Ground Gas Risk Assessment”

CL:AIRE research bulletin RB 17, 2012

- Only to be used for very low to moderate onsite gas hazard
- Requires carefully planned and executed investigation
- Uses TOC analysis and forensic logging



Boreholes and Monitoring Wells



Taken from NHBC guidance



Boreholes and Monitoring Wells

SAMPLES & TESTS			STRATA				Geology Instrument/ Backfill
Depth	Type No	Test Result	Water Reduced Level	Legend	Depth (Thick- ness)	DESCRIPTION	
0.50 0.50	D1 ES1				(1.80)	MADE GROUND: Firm, locally stiff, light brown and light grey, locally grey-brown, slightly sandy, slightly gravelly CLAY with ash. Gravel comprised fine to coarse, sub-angular to rounded flint, brick and sandstone. 1.50 PID result = 1.6ppm	
1.50 1.50	D2 ES2				1.80	MADE GROUND: Firm, grey-brown and light brown mottled, locally dark grey, slightly sandy, slightly gravelly CLAY. Gravel comprised fine to coarse, sub-angular sandstone and brick. 2.50 PID result = 1.7ppm	
2.50 2.50	D3 ES3				(1.60)		
					3.40		
					3.60	MADE GROUND: Red-brown, silty, sandy GRAVEL of fine to coarse brick GRAVEL.	
3.70 3.70	D4 ES4				3.80	MADE GROUND: Firm, light grey, locally orange-brown, slightly gravelly CLAY. Gravel comprised fine to medium, sub-angular sandstone.	
					(0.90)	MADE GROUND: Light grey, locally dark grey, GRAVEL of medium to coarse sub-angular sandstone.	
					4.70		
					5.00	MADE GROUND: Firm, locally soft, grey and black organic CLAY	

Valuable data source – treat them like a scientific instrument

- Supervise their drilling and installation
- Provide as much description as possible in line with BS5930 and BS10175 within the logs and add further forensic descriptions
- Take downhole (profile) gas readings and soil samples
- Carefully select the appropriate screening horizon
- Don't forget to seal both below and above the response zone with appropriately hydrated bentonite

Boreholes and Monitoring Wells



Valuable data source – treat them like a scientific instrument

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Periodic Monitoring

PROJECT ID:

SITE:

DATE:

SPECIALIST:

Doc Ref: QMS-SGMF

Issue.v1.8

EQUIPMENT		WEATHER CONDITIONS		GROUND CONDITIONS / GENERAL COMMENTS	
Model	Serial Number	Clear sky, dry, moderate wind, 18° C.		Ground dry, cracked in places. Little to no vegetation throughout Parcel 2, with shell fragments along the south and south west part of the parcel. Sand	
GasData GFM 430	10356				
PhoCheck Tiger	105553	Start Pressure (mb): 1021 End Pressure (mb): 1018			
Dip Meter	N/A				

BH ID	Time	Barometric Pressure [mb]	Line Test OK?	External Flow [ltr/hr]			TVOC [ppmv]	Steady CH ₄ [%v/v]	Peak CH ₄ [%v/v]	Steady CO ₂ [%v/v]	Peak CO ₂ [%v/v]	O ₂ [%v/v]	CO [ppmv]	H ₂ S [ppmv]	SWL [mbgl]	Base Dip [mbgl]	Con
				Initial	Duration	Steady											
Fresh Air	12:33	1021	OK	NM	N/A	NM	0.0	0.0	0.0	0.0	0.0	20.6	0	0	N/A	N/A	
W55_5	14:50	1017	OK	17.9	>1 min	17.9	0.8	0.0	0.0	1.6	1.6	17.4	0	0	Dry	5.95	
W55_6	14:40	1018	OK	18.4	>1 min	18.4	0.2	0.0	0.0	3.4	3.4	12.2	0	0	Dry	6.00	
W55_10	13:30	1020	OK	0	N/A	0	1.0	0.0	0.0	0.4	0.4	18.1	0	0	Dry	5.97	
W55_13	12:40	1021	OK	0	N/A	0	0.2	0.0	0.0	0.0	0.0	19.5	0	0	Dry	5.80	
W55_14	13:00	1021	OK	0	N/A	0	1.1	0.0	0.0	30.4	30.4	5.8	0	0	Dry	5.77	
BH5_35	14:20	1019	OK	1.9	>1 min	1.9	0.4	0.0	0.0	4.2	4.2	14.7	0	0	Dry	2.96	



Periodic Monitoring



Experts in Continuous Monitoring



WEATHER CONDITIONS	GENERAL COMMENTS / H&S NOTES
Sunny Strong easterly breeze	4 open sledge lagoons, and sledge cube deposits on site
GROUND CONDITIONS	MONITORING WELL COMMENTS
Site is mostly dry, with some pooling water	Old raised headwork, heavily rusted and cover rusted open. Flooded 50mm standpipe. Rubber bung with single valve fitted (closed) Water sucked into monitoring tube - quickly disconnected

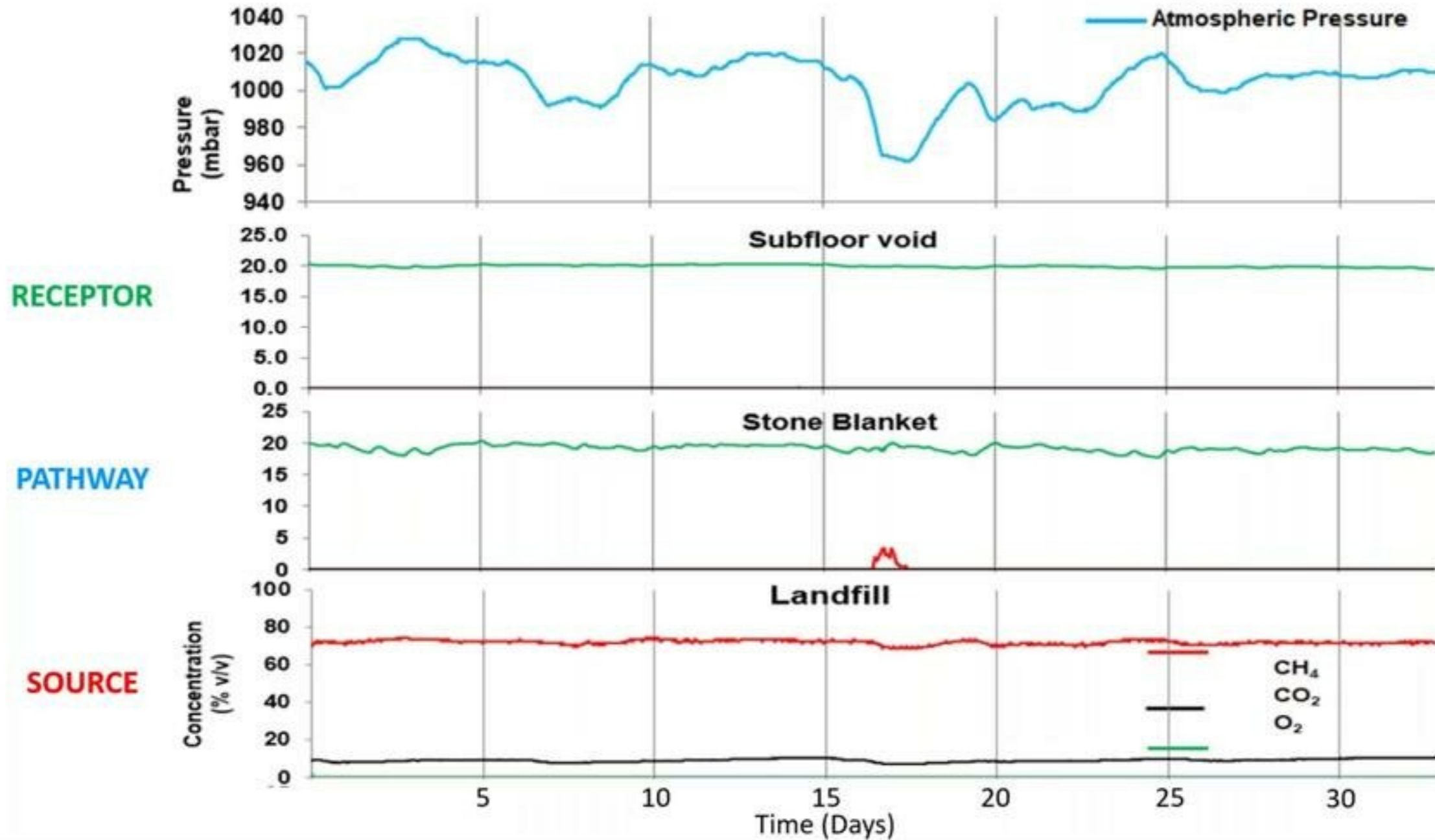
PROJECT DETAILS			
Project ID		Date	13/09/2019
Site		Time	12:45
Specialist	JN		
EQUIPMENT			
Model	Serial Number		
GA 5000	G504460		
Geotech Dip Meter	201162		
BOREHOLE DETAILS			
Borehole ID	BH 112		
Groundwater Level (mbgl)	0.68		
Depth to base (mbgl)	6.18		
Atmospheric Temp (°C)	16		
	Start	End	
Atmosphere pressure (mb)	1010	1010	
Borehole Pressure (mb)	am	am	

TIME (seconds)	Gas Flow Litres/hour	Gas Readings							
		CH ₄ (% v/v)	CO ₂ (% v/v)	O ₂ (% v/v)	BAL	CO (ppmv)	H ₂ S (ppmv)	TVOC (ppmv)	
Fresh Air	0.0	0.0	0.0	20.9	79.1	0	0	0	
Initial	9.4	87.6	0.5	0.4	12.1	0	0	0	
30	8.2	87.6	0.5	0.3	11.6	0	0	0	
60	7.6	87.6	0.5	0.3	11.6	0	0	0	
90	6.1	87.6	0.5	0.3	11.6	0	0	0	
120	5.1	87.6	0.5	0.3	11.6	0	0	0	
150	3.1	87.6	0.5	0.3	11.6	0	0	0	
180	2.3								
240	1.2								
300	0.0								

STEADY STATE FINAL RESULTS									
	Flow (l/hr)	CH ₄ (%)	CO ₂ (%)	O ₂ (% v/v)	BAL	CO (ppm)	H ₂ S (ppm)	TVOC (ppm)	
Steady state time (s)	<30	<30	<30	<30	<30	0	<30	0.0	
Steady state value	1.2	87.6	0.5	0.3	11.6	0	0	0.0	
Peak Value (O ₂ Low)	3.4	87.6	0.5	0.3	12.1	0	0	0	

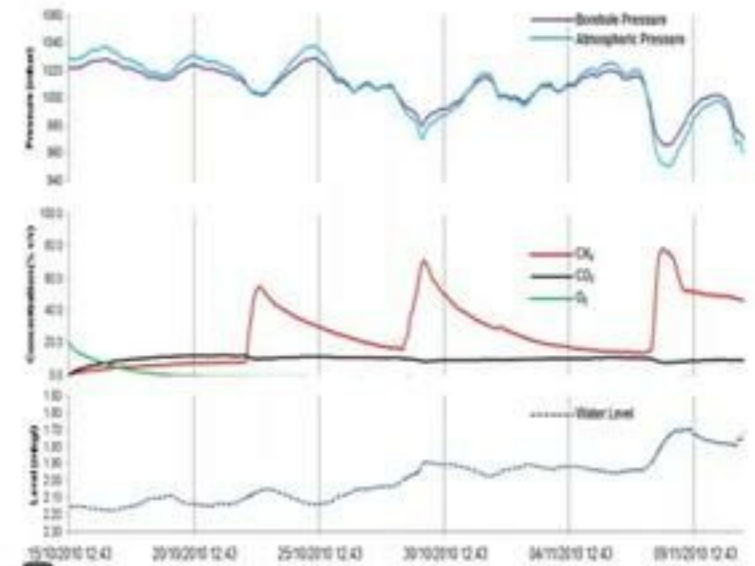
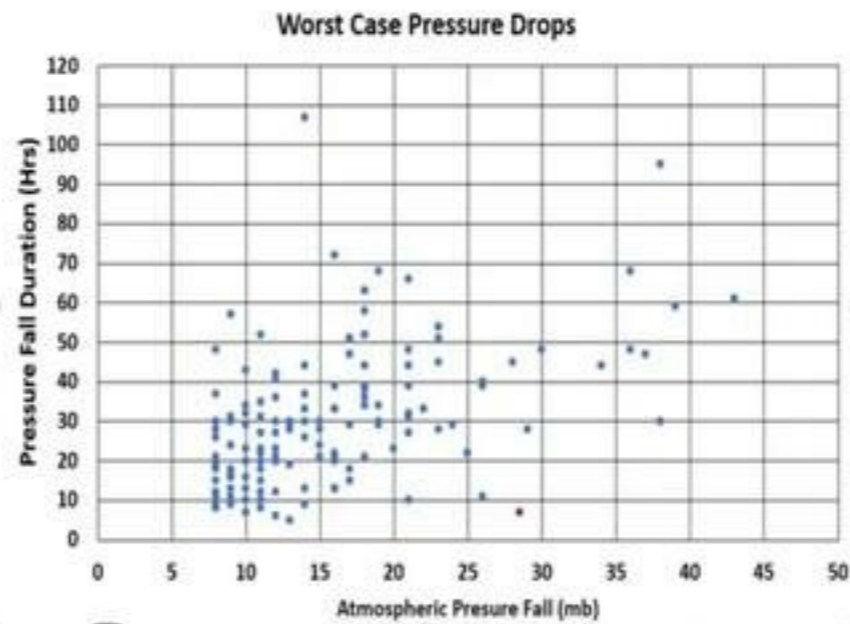
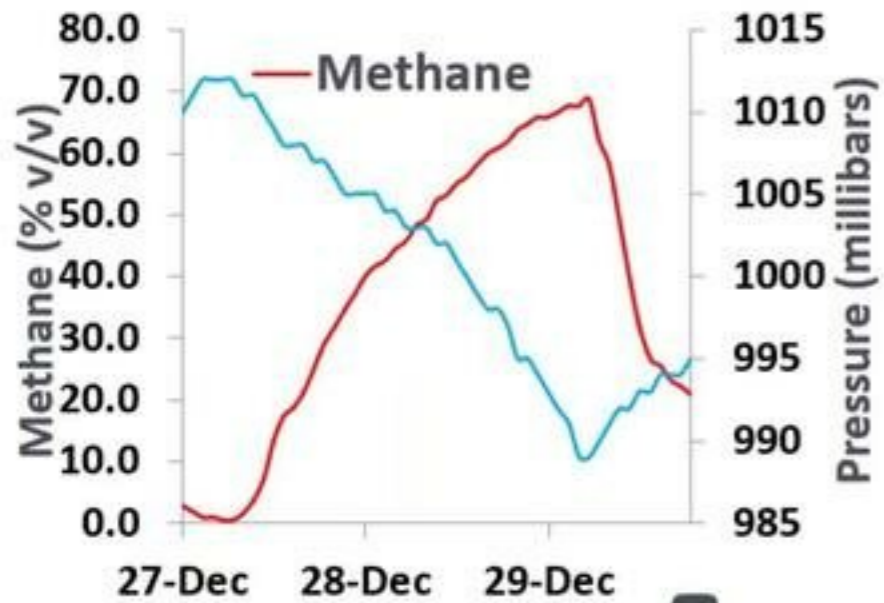
KEY: 0.0 = Below instrument limit of detection, NM = Not Measured, N/A = Not Applicable, %v/v = Percentage volume by volume, ppmv = parts per million by volume, mb = millibar, l/hr = litres per hour, mbgl = metres below ground level, OS = off scale of instrument

S-P-R Monitoring

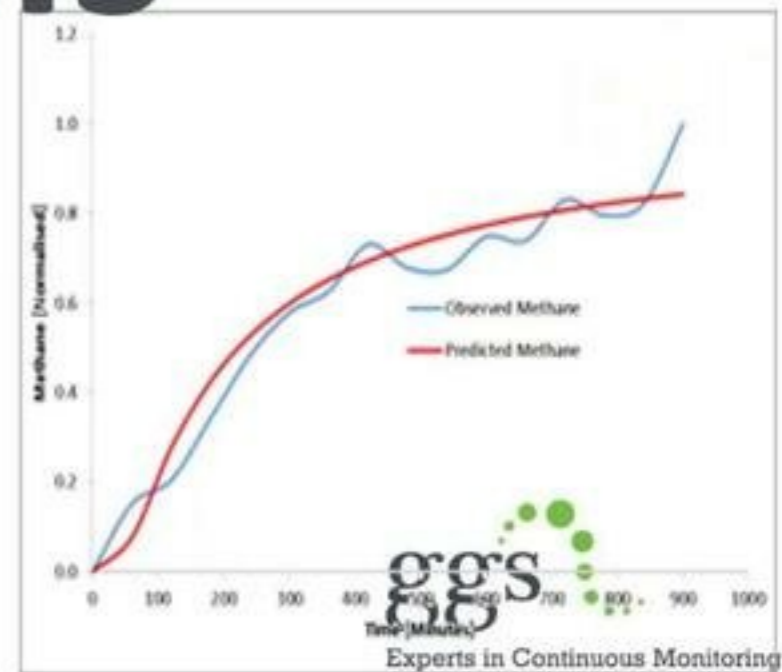
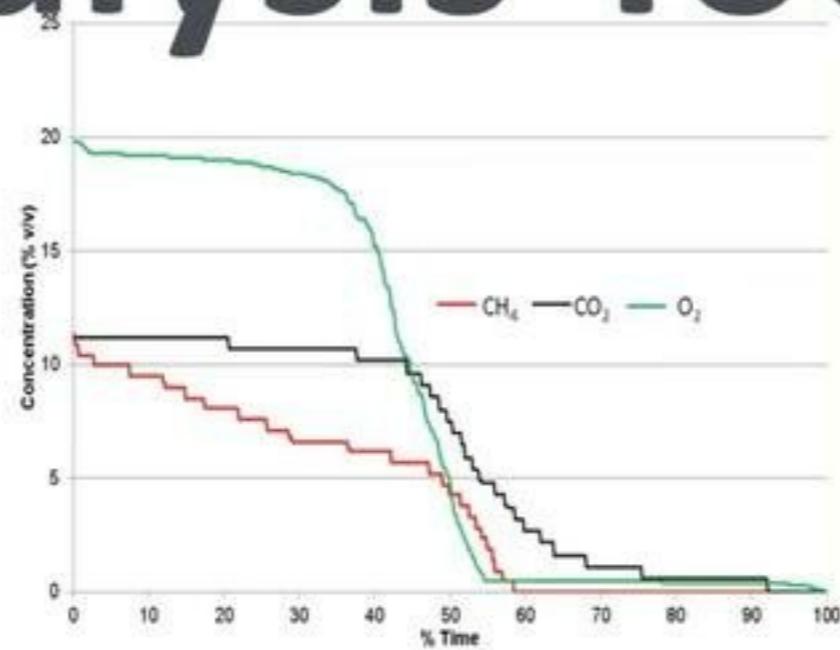
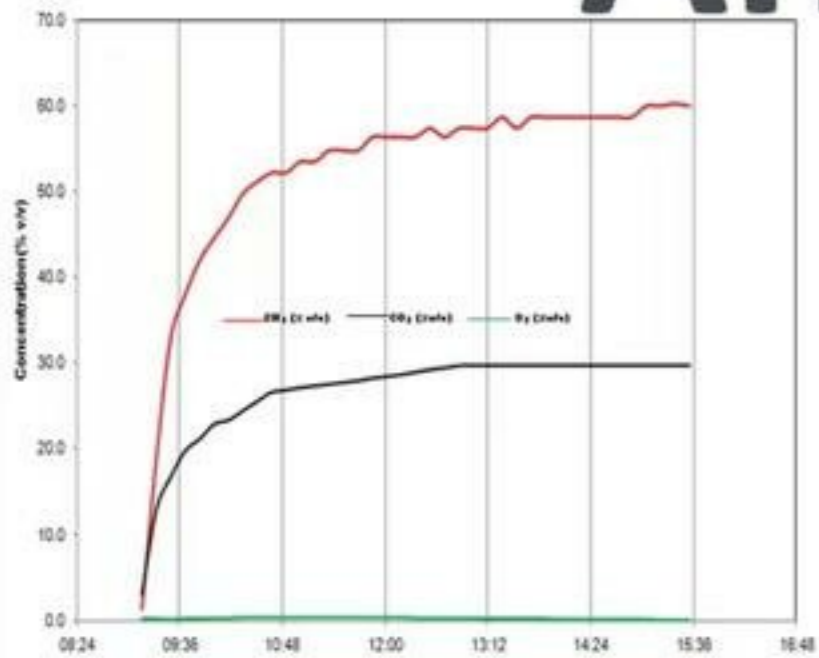


Receptor Monitoring





Analysis Tools



Environmental Correlations

Multi-parameter continuous data allows correlations to be drawn between environmental parameters and ground-gas concentration, to identify ground-gas drivers

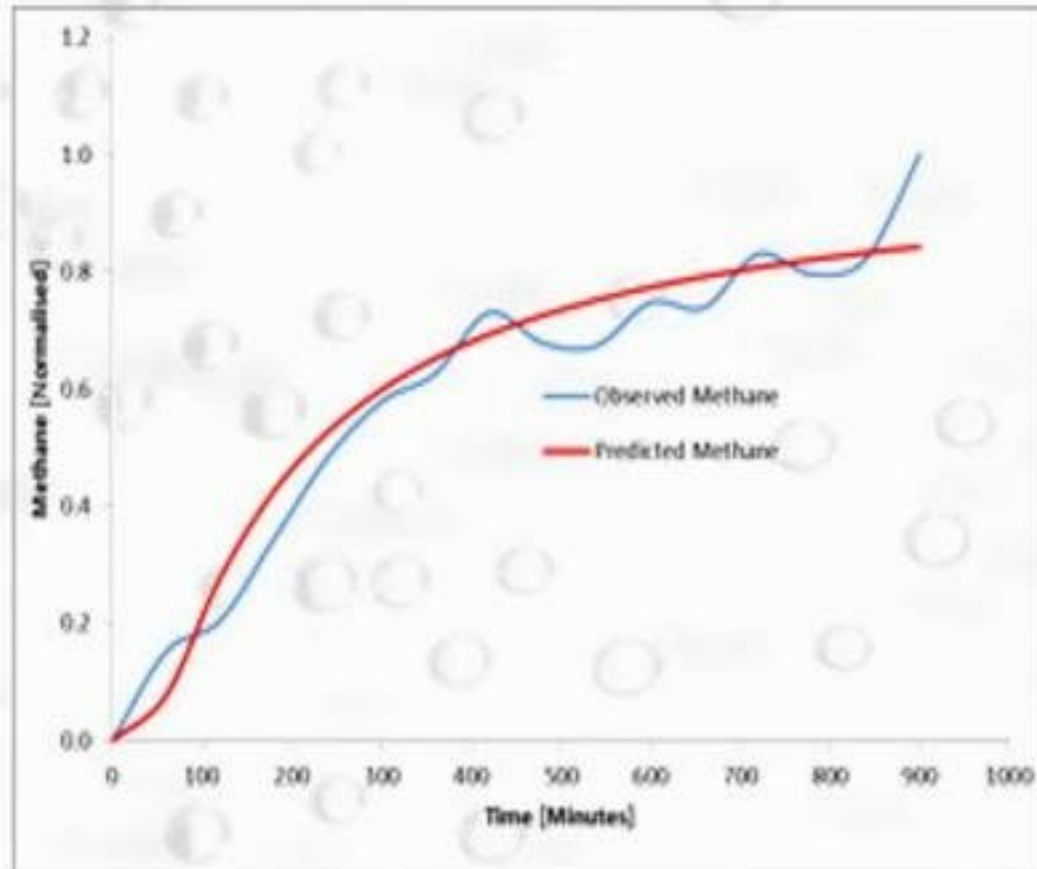
Ground-gas drivers include:

- Atmospheric pressure
- Borehole pressure
- Temperature
- Ground-water levels



Variables showing no correlation with ground-gas concentration may be eliminated

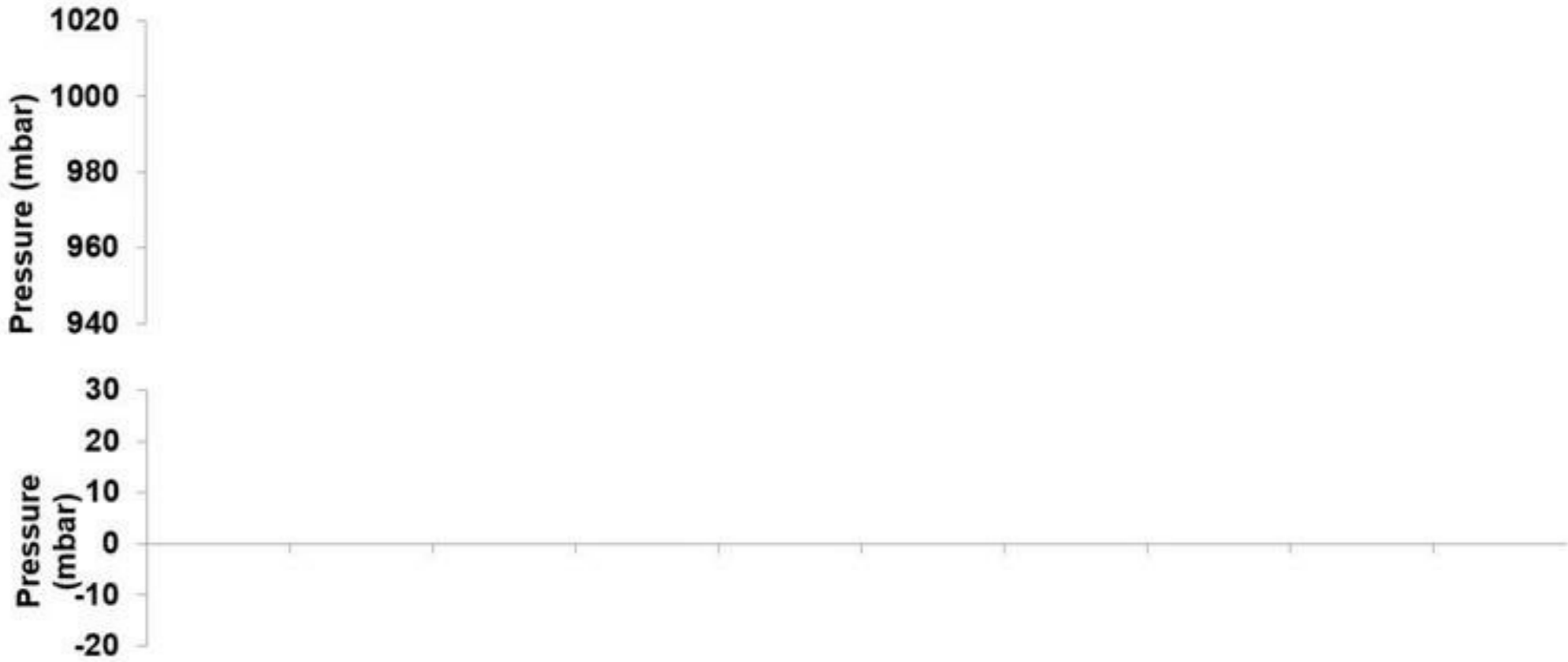
Dissolved Gases



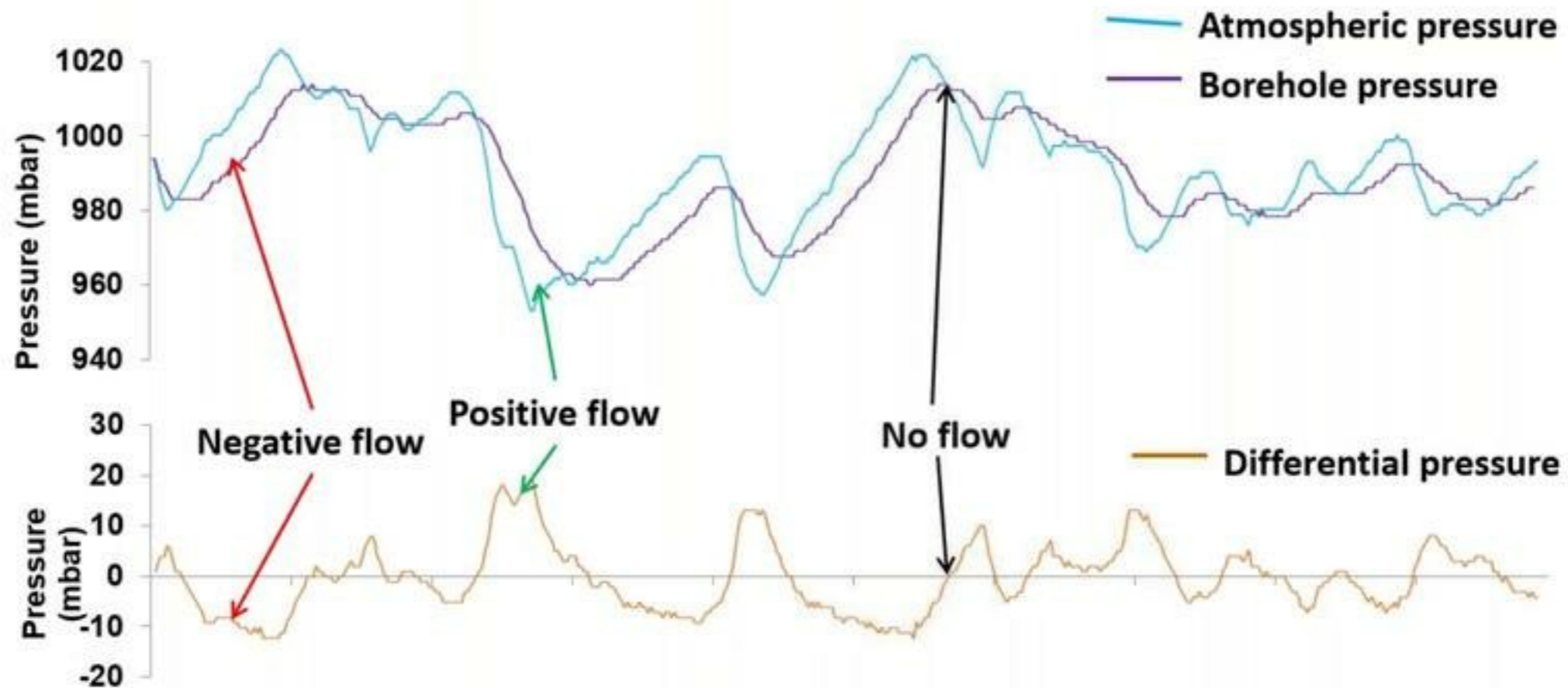
- Dissolved gases behave differently than free gas and need a different approach
- Typically gas will partition out of solution via diffusion until it reaches equilibrium
- Where there is a trapped headspace of limited volume, gas concentrations can be highly elevated
- Be careful with deeper or pressurised sources

if just 1.6mg/l of dissolved methane were to completely degas then it could give rise to approximately 5% v/v in a borehole

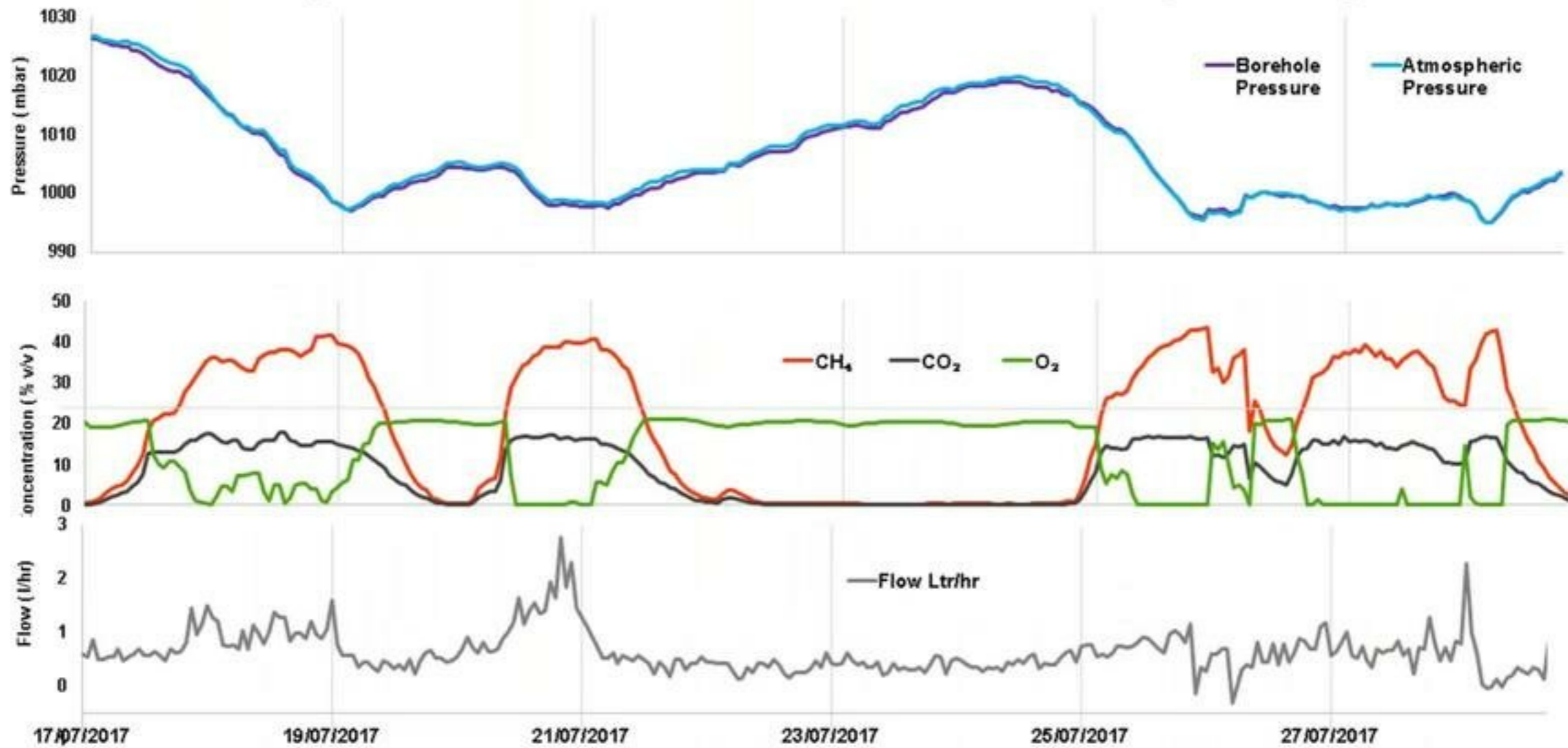
Differential (Static) Pressure Assessment



Differential (Static) Pressure Assessment

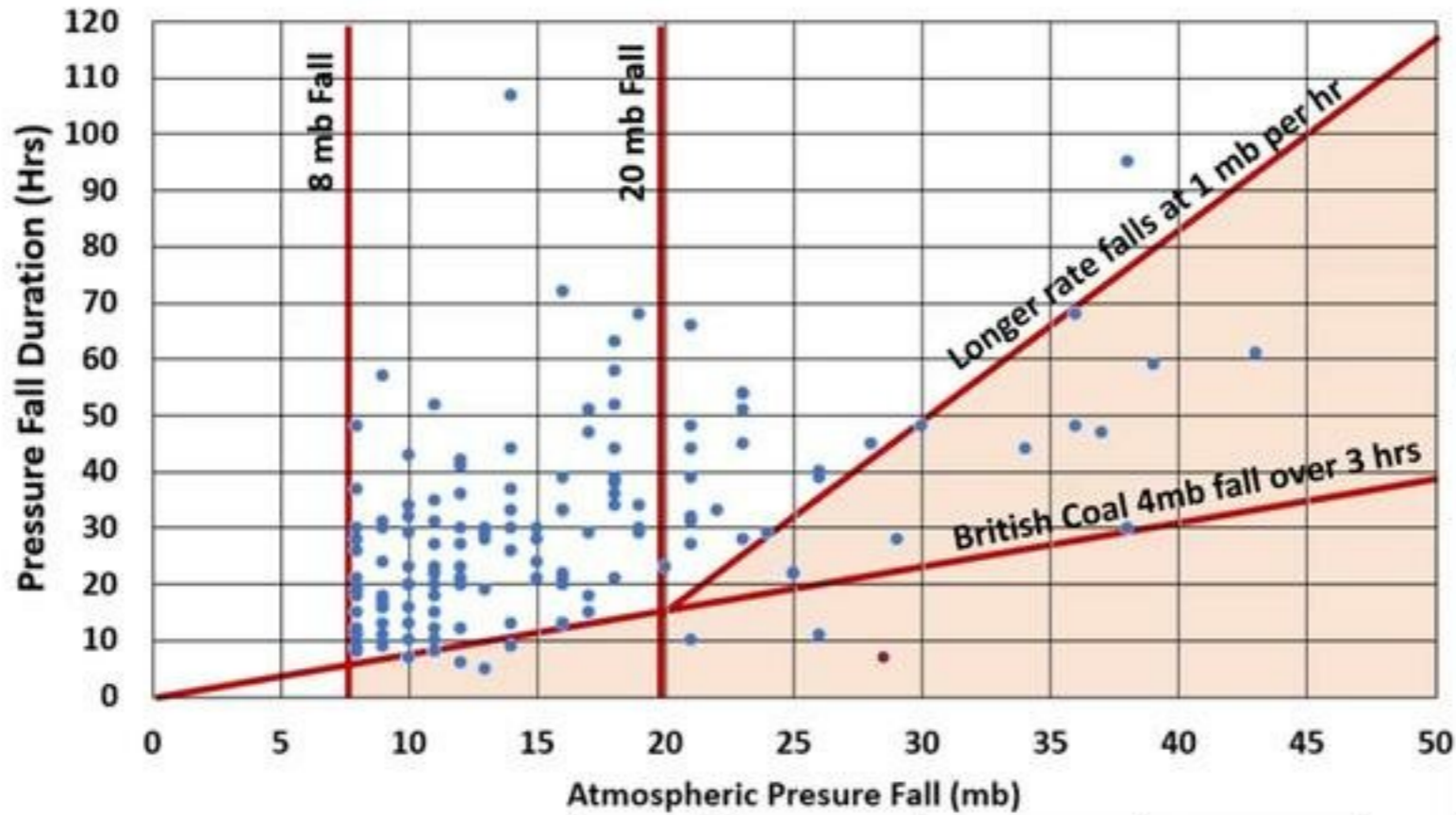


Dynamic Pressure Assessment (Flow!)



GGG GasSentinel® Time Series

Worst Case Pressure Drops



Worst-Case Zone

	Pressure Fall (mb)	Time (Hrs)	Rate of Fall (mb/Hrs)
n	138	138	138
Max	43	107	2.60
Min	8	5	0.13
Mean	15.8	30.6	0.64
Median	14	28.5	0.53
St Dev	7.6	17.5	0.40
95th	34.3	61.3	1.28
90th	25.3	52	1.08
80th	21	44	0.82
75th	19	39	0.76

Modelling

- Simple spreadsheet based calculations to quiet sophisticated commercial modelling packages
- 1D modelling using basic principles: Boyles Law, Darcy's Law, Fick's Law (and others)
- Concentration modelling 2D surface and 3D plots with time dimension
- CLEA, USEPA J&E v6, GasSim2.5 (and others)
- Unfortunately it is very easy to get sucked into the numbers and forget reality!
 - Is the model based on sound scientific principles?
 - Is the model appropriate for the site specific circumstances?
 - Have you got realistic numbers for physical parameters?
 - Have you done sensitivity analysis and what factors of safety are you considering?

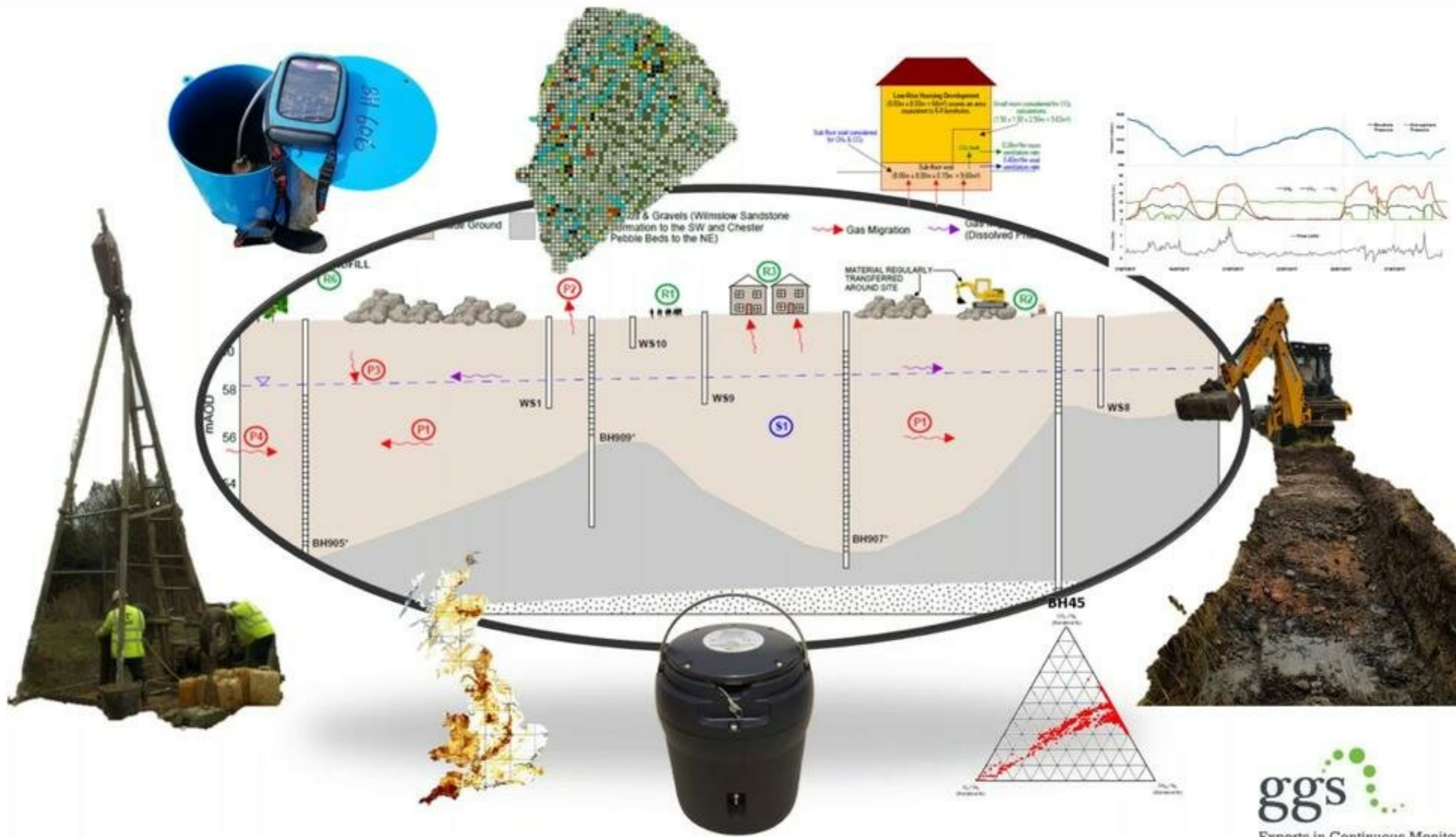


Fault Tree and Event Tree Analysis

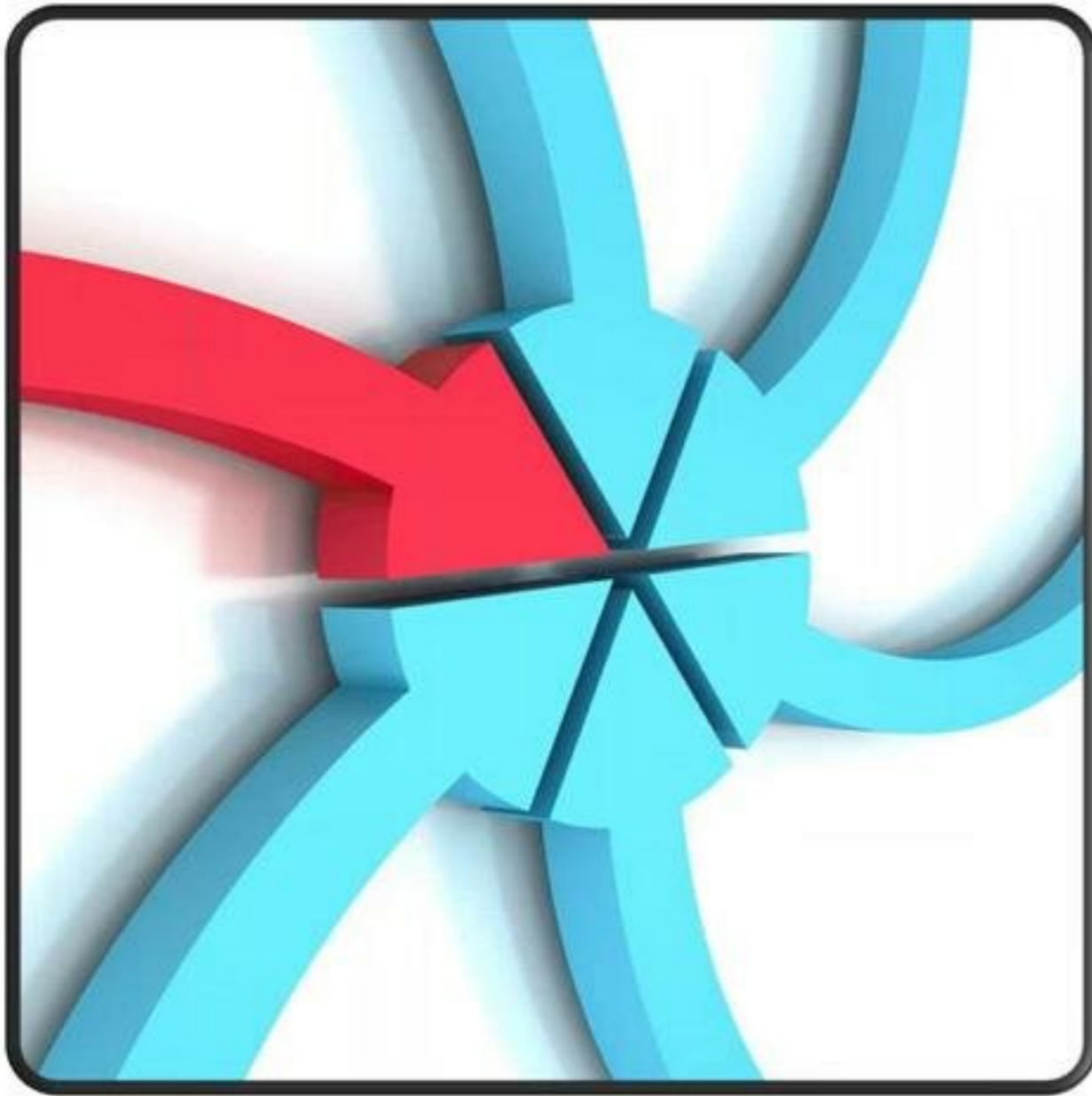
These methods are used to analyse a failure mechanism, looking at a series of failures that lead to an unwanted event

- Fault tree analysis is a 'top down' approach starting with the unwanted event and then looks at individual failures that get you to that event
- Event tree analysis is 'bottom up', starting with an initiating event and follows ever branching time order sequences until you end up with your unwanted event

You can attribute numerical probabilities to the events that provides an estimate of the annual frequency of which such events will occur (F)



Lines of Evidence for Ground Gas Risk Assessment



- Each line of evidence is initially considered separately
- When considered together for a potential pollutant linkage, do they make sense (Converge)
- What weighting are we going to assign
- Confidence (uncertainty) in our evidence
- Used to inform and justify the Conceptual Site Model

Uncertainty (Confidence)

<i>High agreement Limited evidence</i>	<i>High agreement Medium evidence</i>	<i>High agreement Robust evidence</i>
<i>Medium agreement Limited evidence</i>	<i>Medium agreement Medium evidence</i>	<i>Medium agreement Robust evidence</i>
<i>Low agreement Limited evidence</i>	<i>Low agreement Medium evidence</i>	<i>Low agreement Robust evidence</i>

Figure 1 of the Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties 2010

ipcc
INTERGOVERNMENTAL PANEL ON climate change

**Guidance Note for Lead Authors of the
IPCC Fifth Assessment Report on
Consistent Treatment of Uncertainties**

IPCC Cross-Working Group Meeting on Consistent Treatment of Uncertainties
Jasper Ridge, CA, USA
6-7 July 2010

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and Francis W. Zwiers

Uncertainty (Confidence)

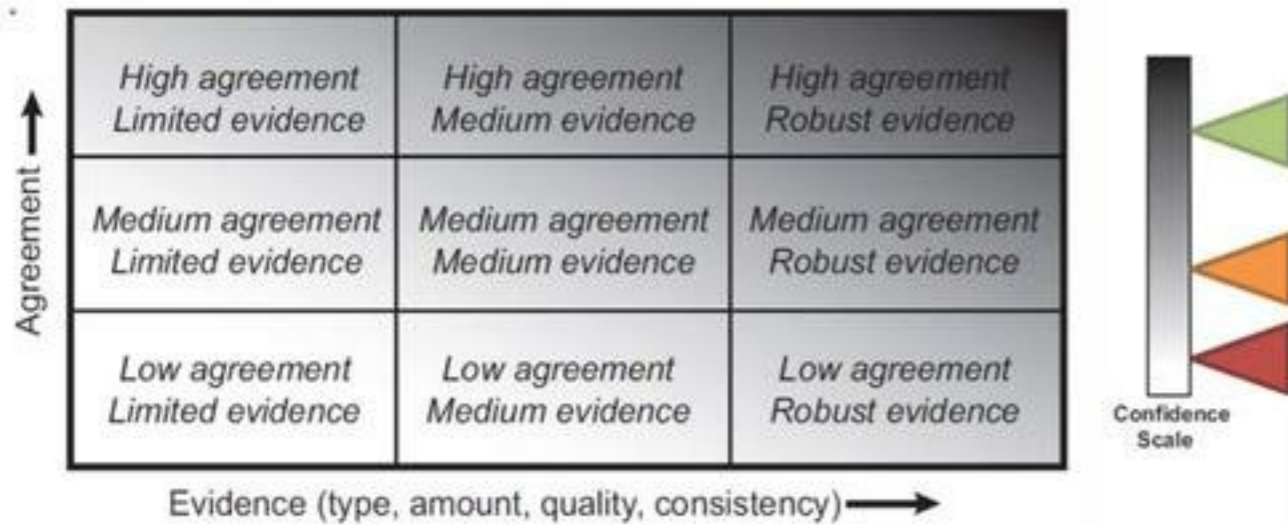


Figure 1 of the Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties 2010



The Unexpected Reading



The Unexpected Reading

Visit No.	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)
1	0	0.2	21.0
2	0	0.5	19.9
3	0	0.3	20.1
4	82.3	6.1	0.5
5	0	0.1	20.6
6	0	0.2	20.2



What factors might effect GSV?

Standpipe and valve diameter

Geology

Gas Reservoir Volume

Gas Modification

Biology

Geochemistry

Gas Generation

Weather Conditions

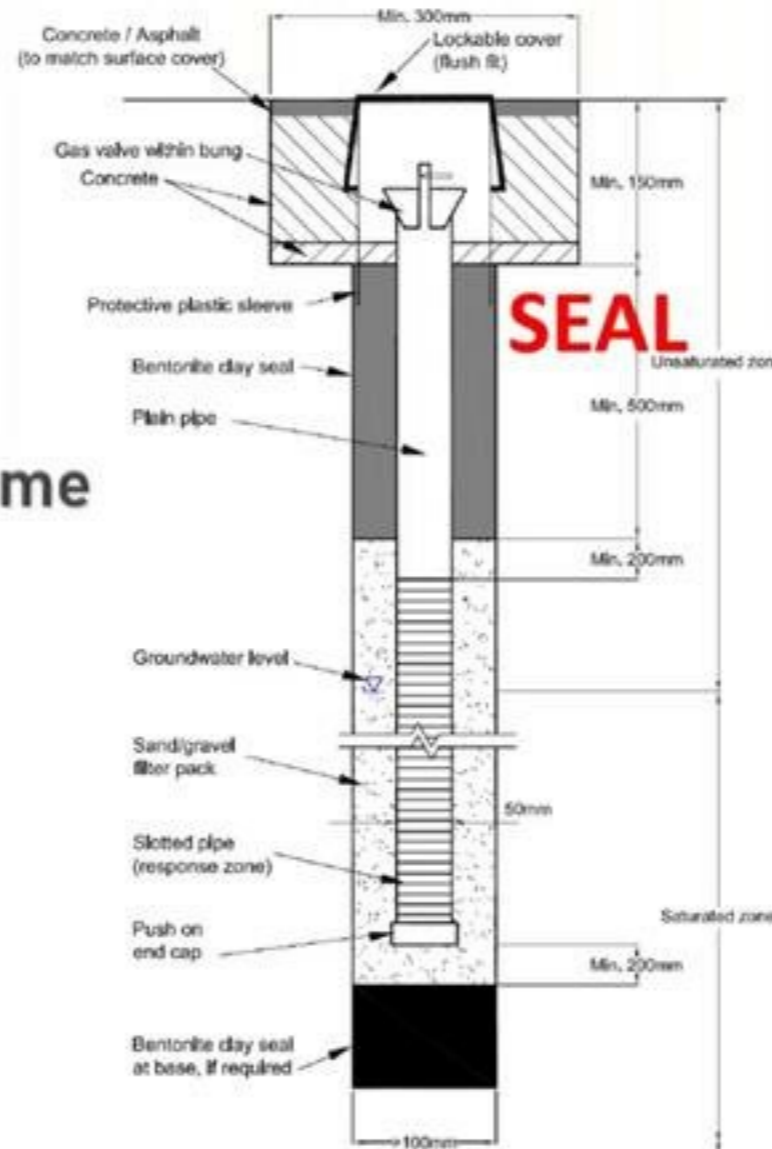
Sampling Equipment

Sampling Methodology

Soil permeability

Response Zone Location

Groundwater



Monitoring Well

(a unique scientific instrument)

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.

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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 enquiry 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 (Cooker and Sannon, 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 Gorbridge incident (O'Brien, 2017), serious ground-gas contamination events still occur. The Gorbridge 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".

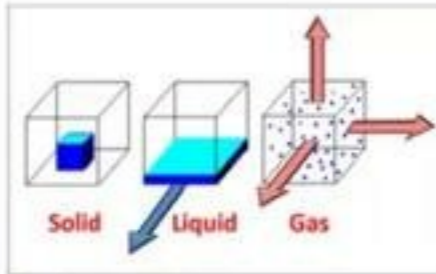


Figure 1. Properties of solid, liquid and gaseous contaminants.

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.

If you would like further information about other CL:AIRE publications please contact us at the Help Desk at www.clare.co.uk

CL:AIRE TB18 - Jan 2019

- Built on over 12 years experience of continuous monitoring
- Over 500 projects reviewed
- Ground-gas properties and behaviour
- Best practice in collecting continuous data
- Gas behaviour within the Source-Pathway-Receptor
- Lines of evidence approach to risk assessment

What about project timescales?



What about project costs?



Experts in Continuous Monitoring

Thank You

Any questions?

<http://www.ggs-uk.com>

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